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PH SERIES

INSTRUMENT DIVISION

POWER SUPPLIES

DOCUMENT NO. 120021-01

OPERATING AND SERVICE MANUAL

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FSCM No. 52542

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SYSTRON DONNER
INSTRUMENT DIVISION
2727 Systron Drive
Concord, California 94518

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June, 1985

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CHAPTER 1
GENERAL INFORMATION

1.1 INTRODUCTION

The P-Series power supplies consists of four PQ Quarter-rack supplies and four PH Half-rack supplies. These supplies may be operated locally via the front panel controls or switch selected for remote operation using a remote program source. The Systron Donner P-1 and P-2 Programmer modules provide all the logic necessary to control the P-Series supplies via an IEEE STD-488 GPIB.

Table 1-1 provides a listings of the eight modules that make up the P-Series power supply system.

TABLE 1-1 P-SERIES MODULES

MODULE	FUNCTION AND CHARACTERISTICS
PQ 10-3	Programmable 0-10V, 0-3A Quarter-rack Power Supply
PQ 20-2	Programmable 0-20V, 0-2A Quarter-rack Power Supply
PQ 50-1	Programmable 0-50V, 0-1A Quarter-rack Power Supply
PQ 100-0.5	Programmable 0-100V, 0-0.5A Quarter-rack Power Supply
PH 10-10	Programmable 0-10V, 0-10A Half-rack Power Supply
PH 20-6	Programmable 0-20V, 0-6A Half-rack Power Supply
PH 50-3	Programmable 0-50V, 0-3A Half-rack Power Supply
PH 100-1.5	Programmable 0-100V, 0-1.5A Half-rack Power Supply

This instruction manual contains the general characteristics and specifications, operating procedures, theory of operation, maintenance and calibration procedures, parts lists and the related schematic diagrams and assembly drawings for all the modules that comprise the P-Series power supplies.

The P1, P1E, and P2 Programmer modules that provide the remote programming for the power supplies are not included in this instruction manual. If the Power Supplies are to be system configured, utilizing programmer modules refer to the P1 and P2 Programmer Instruction Manual for detailed information on system configuration, programmer data and operation and maintenance of the Programmer modules.

1.2 DESCRIPTION

The P-Series power supplies are modular in design to allow a compact multiple output programmable system configuration for use in test and process-control systems when used in conjunction with the P-Series programmer(s). The programmer will allow up to eight power supplies to be controlled via a General Propose Interface Bus (GPIB) which conforms to IEEE STD-488-1975 or locally via the programmer front panel data switches. The power supplies will respond to program changes in less than 2 milliseconds. Each Power Supply module may be controlled locally by its front panel control settings when the local

modes are rear panel switch selected. The Power Supply modules are lightweight, compact precision dissipative regulators housed in quarter and half rack chassis having equal height and depth, thus allowing a compact multiple output rack assembly. Both constant voltage and constant current operation is provided, which may be either locally controlled or remotely programmed. In the voltage mode, adjustable current limiting is provided, while the current mode provides adjustable voltage limiting. Both output voltage and current are front panel metered, and front panel indicators provide indication of the operational mode of the supply.

1.3 SPECIFICATIONS

Table 1-2 lists the power supply power ratings. The performance specifications describe the power supply's warranted performance and are listed in Table 1-3. Table 1-4 provides the supplemental characteristics of the power supply which are typical values, but non-warranted performance parameters.

TABLE 1-2 POWER RATINGS

P-Series Model	Output				Sink Current Limit •••	Input	
	Voltage Mode ••		Current Mode				
	Range •	Resistance	Range	Impedance		Voltage	Line Frequency
PQ 10-3	0 to 10 Vdc	20 µΩ	0 to 3 A	3.3 kΩ↔ 11 µF	3.5 A	All models:	All models:
PQ 20-2	0 to 20 Vdc	67 µΩ	0 to 2 A	6.6 kΩ↔ 5.7 µF	2.3 A		
PQ 50-1	0 to 50 Vdc	333 µΩ	0 to 1 A	16.6 kΩ↔ 2.2 µF	1.0 A	90-110 Vac	47-440 Hz
PQ 100-0.5	0 to 100 Vdc	1.3 µΩ	0 to 0.5 A	33.3 kΩ↔ 1.0 µF	.35A	104-127 Vac	
						194-237 Vac	
PH 10-10	0 to 10 Vdc	67 µΩ	0 to 10 A	3.3 kΩ↔ 16 µF	3.5 A	207-253 Vac	
PH 20-6	0 to 20 Vdc	200 µΩ	0 to 6 A	6.6 kΩ↔ 6.6 µF	2.3 A		
PH 50-3	0 to 50 Vdc	1.0 MΩ	0 to 3 A	16.6 kΩ 2.2 µF	1.0 A		
PH 100-1.5	0 to 100 Vdc	4.0 MΩ	0 to 1.5 A	33.3 kΩ 1.0 µF	.35A		

Notes

* An extra 0.5 V per output lead compensates for lead voltage drop.
•• Isolation voltage: 300V terminal to chassis.
••• Nominal value

TABLE 1-3 PERFORMANCE SPECIFICATIONS

PERFORMANCE SPECIFICATIONS	STABILIZATION MODE	
	VOLTAGE	CURRENT
LOAD EFFECT: The change in stabilized output caused by a load change equal to the output rating.	0.002% E-rated	0.05% I-rated or $1mA^2$ + 3 mA whichever is greater
SOURCE EFFECT: The change in stabilized output caused by any change in the ac line within the input rating.	0.001% E-rated	0.005% I-rated or 200 µA whichever is greater

TABLE 1-3 PERFORMANCE SPECIFICATIONS (Cont'd)

PERFORMANCE SPECIFICATIONS	STABILIZATION MODE	
	VOLTAGE	CURRENT
PARD: Periodic and random deviations from the stabilized output, measured from 20 Hz to 10 MHz.	300 µV rms or 3 mV p-p	0.05% I-rated, or 1 mA, RMS whichever is greater 0.15% I-rated, or 3 mA, p-p whichever is greater
STEP RESPONSE TIME: The time required to achieve 99.9% of the programmed change with a resistive load.	2 ms	1 ms

With a capacitive load, voltage stabilization may be delayed because current, charge or discharge, is limited. When the load capacitance is known, the step response time can be calculated using the equation below C_i is the supply's internal capacitor (see output ratings) and I_1 is the sink or source current limit. The units of measure are seconds, volts, farads and amperes.

$$\text{Time} = \frac{\Delta E \ (C_i + C_e)}{I_1}$$

TABLE 1-4 SUPPLEMENTAL CHARACTERISTICS

SUPPLEMENTAL CHARACTERISTICS	STABILIZATION MODE	
	VOLTAGE	CURRENT
DRIFT: The output drift over 8 hours under constant line, load and temperature after a 30-minute warmup.	0.01% E-rated in Local 0.005% E-rated in Remote	0.1% I-rated or 3 mA* in Local 0.02% I-rated in Remote
TEMPERATURE EFFECT: The change in stabilized output per °C change in ambient temperature.	0.01% E-rated in Local 0.005% E-rated in Remote	0.01% I-rated in Local or Remote
RESOLUTION: The resolution obtainable with front panel controls.	0.03% E-rated	0.06% I-rated
PROGRAMMING SCALE: The external input that will change the output from minimum to maximum.	0 to +10V @ 1 mA Voltage and V_{LIM} ®	0 to -1 mA @ -1V

TABLE 1-4 SUPPLEMENTAL CHARACTERISTICS (Cont'd)

SUPPLEMENTAL CHARACTERISTICS	STABILIZATION MODE	
	VOLTAGE	CURRENT
TRANSIENT RECOVERY: Time required to recover within 0.1% E-rated following a step load change between 10% and 100% of I-rated.	50 µs	
METER ACCURACY: The maximum non-linear error at 25°C.	2%	2%
V_{LIM} ® ADJUSTMENT RANGE:	5% to 109% E-rated	
V_{LIM} ® MARGIN: The recommended minimum margin of setting above output voltage.	5% E-rated	
CROWBAR TRACKING RANGE:	5V to 110% E-rated **	
CROWBAR THRESHOLD: The voltage above V_{LIM} ® at which the crowbar will trip.	1% E-rated 50 µs response	

Notes:
* Whichever is greater
** 50V and 100V models 7V to 110%

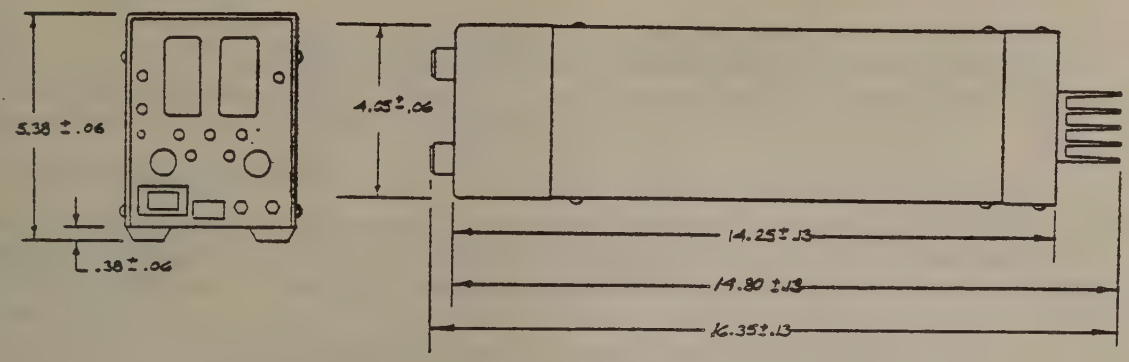
1.4 PHYSICAL CHARACTERISTICS

Table 1-5 lists the P-Series power supplies physical characteristics. Figure 1-1 provides outline drawings with dimensional data.

TABLE 1-5 PHYSICAL CHARACTERISTICS

Storage Temperature:	-40°C to +85°C	
Dimensions:		
PQ Models	Height	5.38" (13.7 cm)
	Width	4.05" (10.3 cm)
	Depth	16.35" (41.5 cm)
PH Models	Height	5.38" (13.7 cm)
	Width	8.10" (20.6 cm)
	Depth	16.35" (41.5 cm)
Weight:		
PQ Models	Net	11 lbs (5 kg)
	Shipping	15 lbs (6.8 kg)
PH Models	Net	23 lbs (10.5 kg)
	Shipping	28 lbs (12.7 kg)

PQ MODELS



PH MODELS

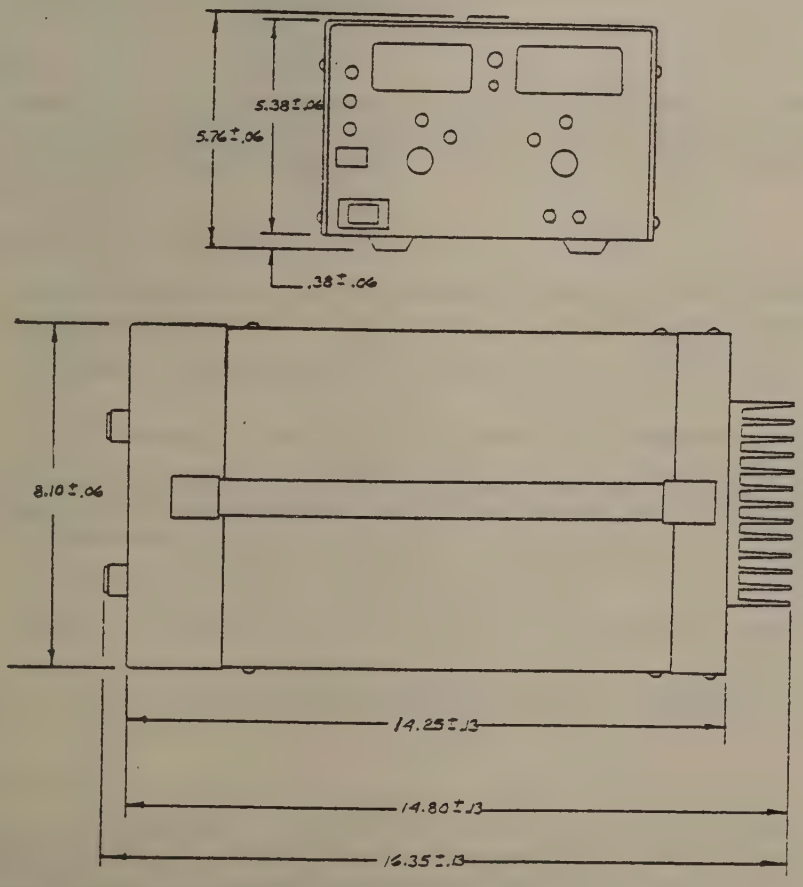


FIGURE 1-1 P-SERIES OUTLINE DRAWINGS

CHAPTER 2

INSTALLATION AND OPERATIONS

2.1 INTRODUCTION

The P-Series Power Supplies are shipped in operational condition and are ready for use as received. This chapter outlines the procedures for initial inspection, installation and operation of the unit. Instructions for reshipment are also included should the unit be returned to Systron-Donner for service or repair.

2.2 RECEIVING INSPECTION

Prior to accepting the unit from the shipper, inspect the condition of the shipping container for any indication of freight damage. Any sign of such damage must be noted by both the shipper and receiver and should be reported to the insurance investigator.

Immediately following removal of the instrument from the shipping carton, inspect for possible physical damage incurred during shipment. Check surfaces for scratches or dents and note condition of controls and connectors. Should any damage be noted, notify your nearest Systron-Donner representative --- DO NOT USE THE POWER SUPPLY UNTIL INSTRUCTED TO DO SO BY THE REPRESENTATIVE.

2.3 RESHIPMENT

When the instrument is to be repackaged for shipment use the original packing materials. Your Systron-Donner field-office can provide materials similar to those used for the original factory packaging, or repackage the instrument following these general instructions.

General packaging instructions:

1) Attach a tag to the unit indicating the model number, serial number, name and address of the instrument owner, and a summary of the service or repairs required.

2) Wrap the instrument in heavy paper or plastic prior to placing it into the shipping container.

3) Select a strong carton or wooden box to house the instrument.

4) Use an adequate layer of shock-absorbing material on all sides of the instrument and protect the front panel with additional layers of cardboard. Be certain that there is no movement of the unit within the container.

5) Seal the package with strong tape or metal bands.

6) Mark the shipping container "FRAGILE-DELICATE INSTRUMENT" to ensure careful handling.

7) Be certain that all correspondence refers to full instrument nomenclature (model and serial number).

2.4 INSTALLATION

The P-Series power supply may be used as a "stand alone" bench supply installed in its instrument cabinet, or rack mounted in groups to form compact multiple output rack assemblies. They are dimensioned in quarter rack 4.25" (108 mm)

width and half rack 8.5" (216 mm) width, of equal height 5.38" (137 mm) and depth 16.0" (406 mm). Rack mounting assemblies are provided by Systron-Donner to form the following configurations.

2/4 Assembly; Two quarter rack modules in a half rack width assembly.

3/4 Assembly; Mixed quarter and half rack modules in a three-quarter rack width assembly.

4/4 Assembly; Mixed quarter and half rack modules in a full rack mountable unit.

2.5 POWER REQUIREMENTS

The P-Series power supplies are equipped with a standard captive three-conductor power card which when plugged into an appropriate power receptacle, grounds the power supply module to protect operating personnel from certain electrical hazards. Whenever the power card is mated to a two-conductor outlet, a cord adapter plug (properly installed) will provide the same protection.

The instrument operates from an ac power source and by appropriate connection of internal taps from either 90-110 Vac, 104-127 Vac, 194-237 Vac, and 207-253 Vac at 47-440 Hz. Power consumption varies for each model as described in the specifications. Unless requested otherwise, the instrument is normally factory wired for 104-127V ac. Prior to operation ensure the unit is wired for the correct line voltage application. To change operating voltages remove the connections to T101 and rewire in accordance with the transformer connections depicted on the schematic diagram and listed in the following Table 2-1.

TABLE 2-1 POWER TRANSFORMER PRIMARY CONNECTIONS

LINE VOLTAGE	FROM	TO	JUMPER(S) INSTALLED
90-110	S101-1	T101-4	W2, W3
104-127	S101-1	T101-5	W2, W3
194-237	S101-1	T101-4	W1
207-253	S101-1	T101-5	W1

A heavy duty 3-wire line cord with molded NEMA style 5-15P plug provides input power. The power handling ability of the ac lines feeding ac power to the line cord must be considered, as serious losses in regulation and substantial increases in ripple can occur as a consequence of insufficient power handling capacity of these lines. The ac impedance from the breaker box to the power supply input connector should not exceed 0.75 ohms. All ac power line connections must be securely tightened, and any movable electric contact surface (such as the wiper arm of a variable transformer) should be kept clear of impedance producing oxide coatings.

2.6 OUTPUT CONNECTION

Output voltage is available at the rear panel terminal barrier strip TB101. The power supply is shipped from the factory with shorting links connected across the +V and +S and the -V and -S terminals to allow local sensing and regulation. The

shorting links may be removed and sense leads connect to the load to allow remote sensing, noting however, that a voltage drop of 0.5V per power lead must not be exceeded.

NOTE

If the sense leads are not connected to the load or the power supply output terminals, rated output can not be maintained. The power supply must be operated with the sense leads connected, however, built-in circuitry will protect the power supply from damage should a sense lead or shorting link open.

The rear panel barrier strip TB101 is provided with a ground terminal. Either side of the output (+V or -V) may be grounded, or the output may be used in a floating condition, providing that the load circuitry is $\leq$300V as referenced to earth ground.

2.7 FRONT PANEL

The controls, indicators, meters and test jacks located on the front panel of the power supply are described in Table 2-2. Figure 2-1 depicts these locations by index number.

TABLE 2-2 FRONT PANEL FUNCTIONS

INDEX	NAME	FUNCTION
1	LOCAL VOLTAGE CURRENT V_{LIM}	3-green LED indicators, illuminates when the 3-rear panel slot accessible switches are placed in the LOCAL position.
2	ON	A rocker switch that allows for the turn-on and turn-off of the power supply's line power, illuminates when placed in the ON position.
3	VOLTS	A voltmeter that indicates the output voltage of the power supply.
4	AMPERES	A ammeter that indicates the current being supplied to the load by the power supply.
5	V_{LIM}	A red LED indicator that illuminates when the output of the supply is being limited by the V_{LIM} function or when the supply is latched in a OV trip condition.
6	V_{LIM} SET	A recessed screwdriver adjust potentiometer, adjust the set point of the V_{LIM} from 5% to 110% of the rated voltage when LOCAL V_{LIM} is selected.

TABLE 2-2 FRONT PANEL FUNCTIONS (Cont'd)

INDEX	NAME	FUNCTION
7	CONTROL MODE VOLTAGE	A green LED indicator, illuminates when the power supply is operating in the constant voltage mode.
8	CONTROL MODE CURRENT	A amber LED indicator, illuminates when the power supply is operating in the constant current mode.
9	VOLTAGE	A 10-turn potentiometer, adjusts the output voltage of the power supply when local voltage operation is selected.
10	CURRENT	A 10-turn potentiometer, sets the maximum current supplied to the load when local current operation is selected.
11	OUTPUT MONITOR -S +S	2-test jacks, allows monitoring the output voltage of the power supply.

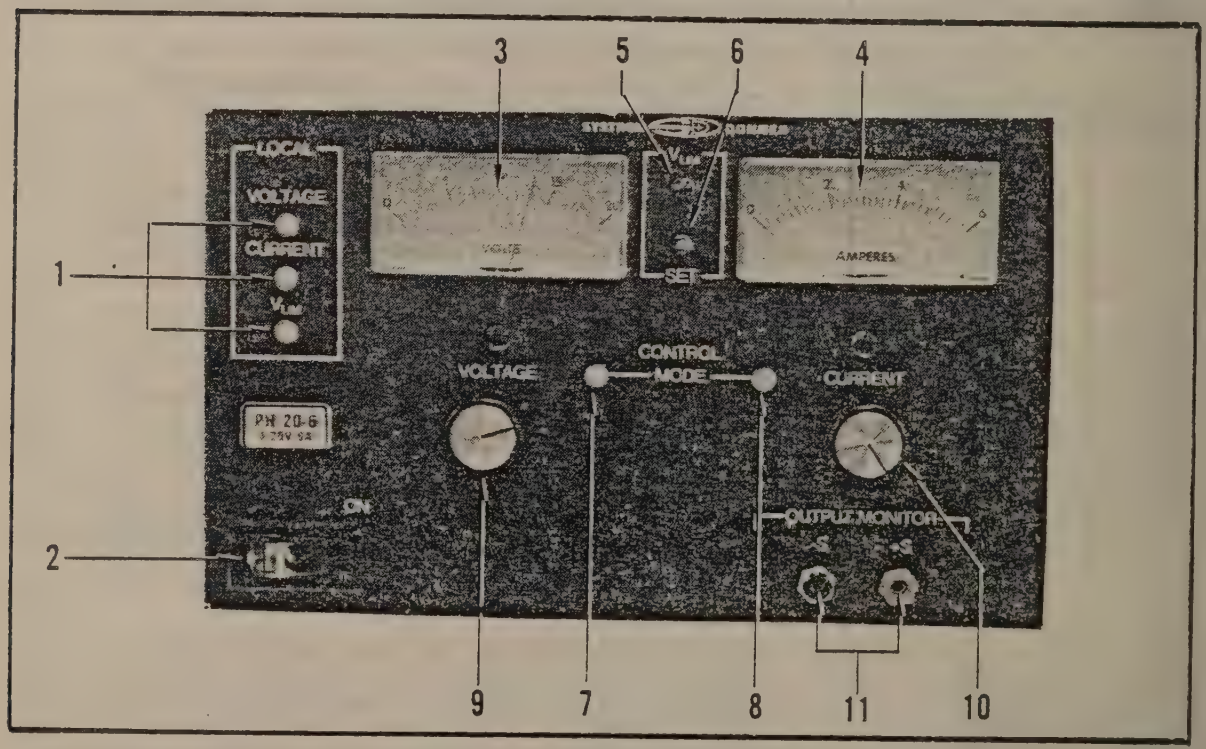


FIGURE 2-1 FRONT PANEL FUNCTIONS

2.8 REAR PANEL

The connectors and switches located on, or accessible via the rear panel of the power supply are described in Table 2-3. Figure 2-2 depicts their location by index number.

TABLE 2-3 REAR PANEL FUNCTIONS

INDEX	NAME	FUNCTION
1	$\overset{+}{V}$ $\overset{+}{S}$ G $\overset{-}{S}$ $\overset{-}{V}$	A 5-terminal barrier strip, provides output, sensing and ground connections for the power supply.
2	115V 1A (3A) 230V .5A (1.5A)	Fuse holder, contains a 1A or 0.5A (3A or 1.5A) 115 Vac or 230 Vac operation respectively
3	J2	An access slot to a 20-pin PCB mounted connector which provides remote programming interface to the power supply. Refer to Table 2-3 for the pin designations of this 20-pin programming connector.
4	REMOTE V I V_{LIM} LOCAL	3-access slots to 3 PCB mounted selector switches that provides for the independent selection of LOCAL control or REMOTE programming of the V, I or V_{LIM} functions.

Table 2-4 provides the pin designations for the rear panel accessed 20-pin programming connector.

TABLE 2-4 PROGRAMMING CONNECTOR J2

PIN NUMBER	FUNCTION
1, A	Interlock (internal interconnection)
2, B	Remote O.V. Trip Signal
3, C	Ground
4, D	+S (All control signals are referenced to +S)
5, E	No connection
6, F	No connection

TABLE 2-4 PROGRAMMING CONNECTOR J2 (Cont'd)

PIN NUMBERS	FUNCTION
7, H	+V -6.2V
8, J	Remote Current Control Input
9, K	Remote V_{LIM} Control Input
10, L	Remote Voltage Control Input

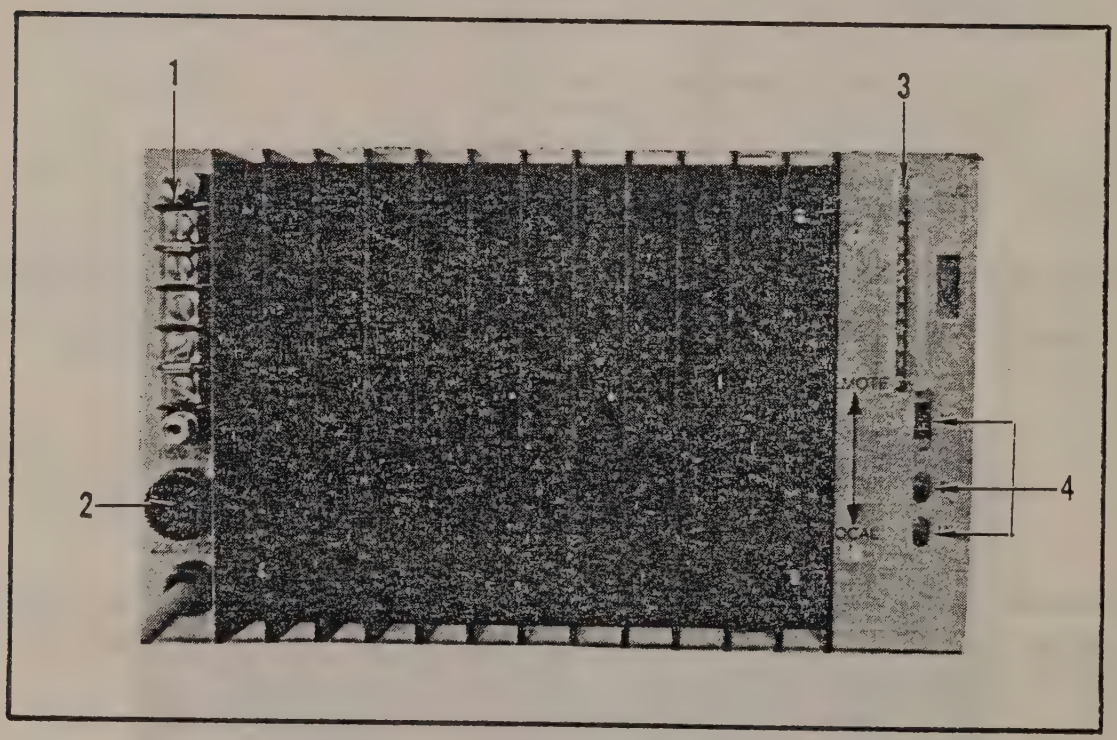


FIGURE 2-2 REAR PANEL FUNCTIONS

2.9 OPERATION

The operation of the power supply may be controlled locally or programmed remotely as to its output voltage, current limiting or V_{LIM} set point. Ascertain which functions are to be controlled locally or programmed remotely and position the rear panel accessed V, I and V_{LIM} switches to there REMOTE (up) or LOCAL (down) positions.

CAUTION

Do Not change the position of the REMOTE-LOCAL V, I or V_{LIM} switches when power is applied to the power supply. Doing so may result in component damage, and power supply failure.

Ascertain if local or remote sensing is to be used. If local sensing is to be used, ensure that the shorting links are installed between the +V and +S and the -V and -S terminals on the rear panel barrier strip. If remote sensing is to be used, open the shorting links between the +V and +S and -V and -S terminals. Connect sense leads between the +S and -S terminals and the load. If long sensing leads are required they should be a shielded twisted pair, with the shield grounded at the power supply and the load end left open. Either side of the output may be grounded or the output may be used in a floating condition. Ensure that the power leads connecting the +V and -V terminals to the load are of sufficient gage to carry the maximum current rating of the power supply (a minimum of 500 circular mils per ampere is recommended).

To determine the proper wire size (AWG) for load leads a nomograph (Figure 2-3) is provided. The wire size is determined by two factors; maximum current carrying capacity recommend for any AWG (500 circular mils per ampere) and the maximum tolerable voltage drop across the load leads.

To find the maximum current capacity for the standard wire size (AWG), lay a straight edge from the AWG on scale 2 to point A on scale 3, then read the maximum off of scale 1.

To find the voltage drop in millivolts per foot for a known wire size and operating current, lay a straight edge from the operating current on scale 1 to the AWG on scale 2, then read the voltage drop on scale 3.

To find the wire size required for a known operating current and a known maximum tolerable voltage drop across the supply leads. First, ascertain the maximum tolerable IR drop in millivolts per foot of lead (sum of positive and negative leads). Then lay a straight edge from this value on scale 3 to the known operating current on scale 1 and read the wire size in AWG off of scale 2.

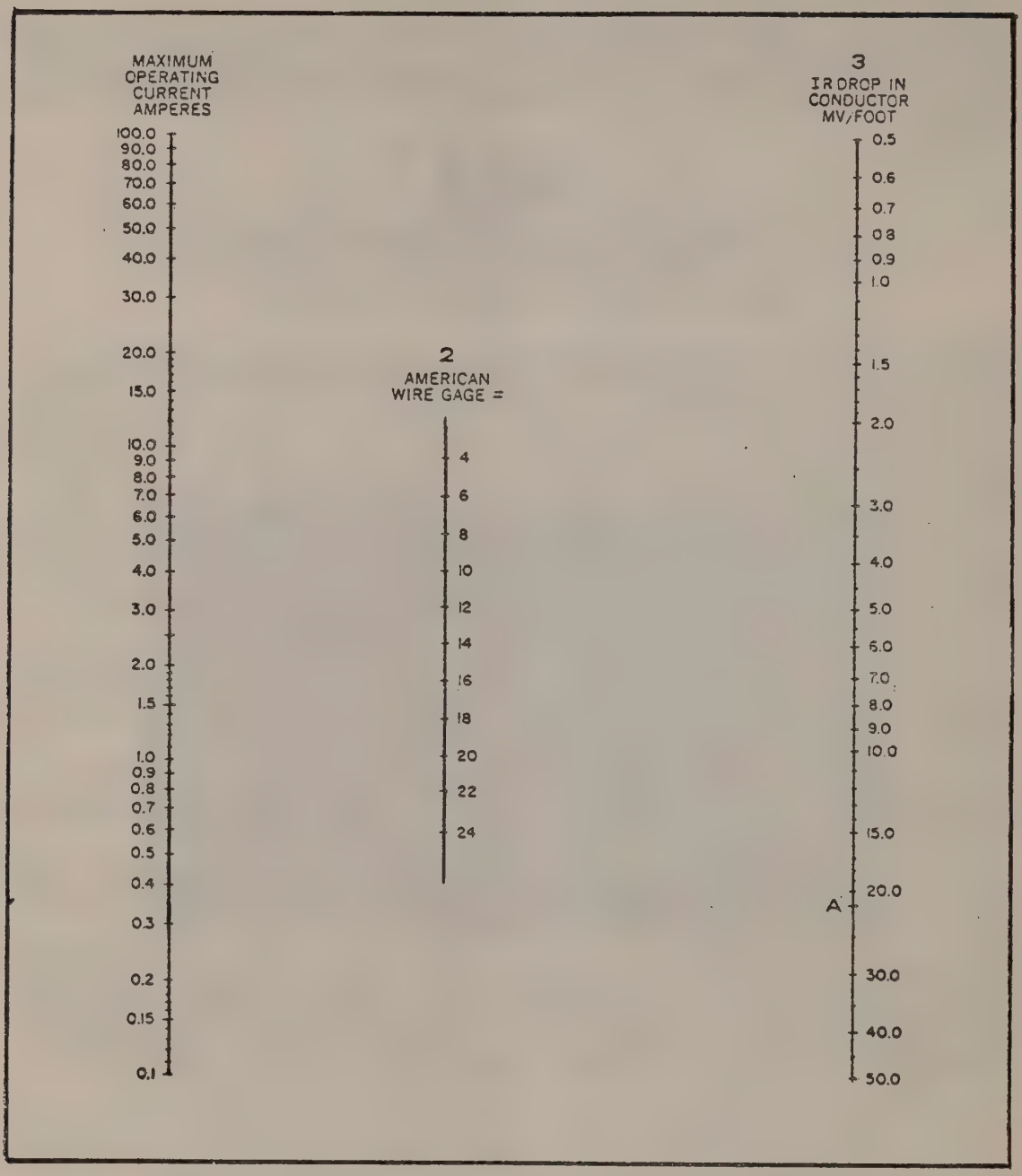


FIGURE 2-3 LOAD LEAD WIRE SIZE MONOGRAPH

2.9.1 Local Control Operation

Set the rear panel accessed V, I and V_{LIM} switches to their LOCAL (down) position. Set the front panel VOLTAGE and CURRENT controls full CCW. Rotate the V_{LIM} SET screwdriver adjustment potentiometer full CW. Set the power switch to its ON position and verify that the power switch indicator illuminates and the LOCAL-VOLTAGE, CURRENT and V_{LIM} LED indicators illuminates. As soon as the power switch is set ON the power supply is ready for use. However, a 30 minute warm-up period is recommended for the supply to reach its rated stability.

To set up the power supply for Constant Voltage Operation With Current Limiting perform the following steps:

1. Monitor the front panel VOLTS meter, or connect a DVM to the OUTPUT MONITOR jacks, and adjust the VOLTAGE control for the required output voltage. If the power supply is equipped with option 09 control locks, lock the VOLTAGE control.

2. Place a short across the +V and -V terminals on the rear panel barrier strip.

3. Monitor the front panel AMPERES meter and adjust the CURRENT control for the required maximum current output (current limit level). If the power supply is equipped with control locks, lock the CURRENT control.

4. Remove the short from the +V and =V terminals.

To set the V_{LIM} level perform the following steps:

1. Monitor the front panel VOLTS meter, or connect a DVM to the OUTPUT MONITOR jacks.

2. Adjust the VOLTAGE control to the required V_{LIM} point, as indicated on the VOLTS meter or DVM.

3. Rotate the V_{LIM} SET screwdriver adjustment CCW until the V_{LIM} LED indicator just illuminates.

4. With the VOLTAGE control reduce the output voltage and verify that the V_{LIM} LED extinguishes. Then slowly increase the output voltage and verify that the V_{LIM} LED illuminates at the required V_{LIM} set point.

5. Reset the VOLTAGE control to the required output voltage and lock the control.

The power supply will provide constant current operation automatically, when the load demand exceeds the current level set by the CURRENT control. When the supply switches into its constant current control mode the CONTROL MODE CURRENT LED illuminates and the CONTROL MODE VOLTAGE LED extinguishes. The point at which the constant voltage/constant current mode change takes place is a function of variations in load conditions and will occur at a critical value of load resistance $R_C = E_S/I_S$, where E_s is the front panel VOLTAGE control setting and I_S is the front panel CURRENT control setting.

2.9.2 Remote Programming Operation

Set the rear panel accessed V, I and V_{LIM} switches to their REMOTE (up) position.

CAUTION

Do Not change the position of the REMOTE - LOCAL V, I or V_{LIM} switches when power is applied to the power supply. Doing so may result in component damage and power supply failure.

Set the power switch to its ON position and verify that the power switch indicator illuminates. Verify that the LOCAL - VOLTAGE, CURRENT and V_{LIM} LED indicators are extinguished, thus indicating that local front panel control of the functions are disabled and the supply may be controlled by a remote programming source. Connect the programming device via cable and connector to the rear panel accessed J2 connector. Table 2-5 provides the remote programming format for the P-Series power supplies.

TABLE 2-5 P-SERIES PROGRAMMING FORMAT

PROGRAM FUNCTION	J2 PIN CONNECTIONS	PROGRAM OPERATION
Voltage Output (V)	10 and L	00.0 to+10.0V provides 00% to 100% of rated the output voltage.
Current Limit (I)	8 and J	0 to-1mA provides 00% to 100% of the rated current limit level.
Voltage Limiting (V_{LIM})	9 and K	00.0 to+10.9V provides 00% to 109% of the rated output voltage as the V_{LIM} set point.

Note: All program input are referenced to the + Sense (+S) J2 pins 4 and D.

NOTE

If for any reason the output voltage of the supply should momentarily exceed the V_{LIM} set point by 1% of the full output voltage rating, the O.V. circuit will trip crowbaring the output of the supply.

The O.V. trip condition is indicated by the illumination of the red V_{LIM} LED and a zero indication on the panel voltmeter. Remotely it is signalled by an O.V. flag as a voltage level between pins 2, B and 7, H of J2.

If no failure has occurred the O.V. trip can be cleared and operation restored by cycling the power ON switch to off and then back ON.

CHAPTER 3
PRINCIPLES OF OPERATION

3.1 P-SERIES FUNCTIONAL DESCRIPTION.

The following functional description is referenced to Figure 3-1 P-Series Functional Schematic Diagram, which depicts the power supply in a simplified form. The schematic diagram located at the end of Chapter 5 of this manuel (Model PH Schematic 7D065445) further supports the circuit analysis of the P-Series power supplies. Reference designators assigned to the electronic components are divided into two numerical series; 1 through 99 PCB assembly mounted components and 101 through 199 chassis, heatsink, front and rear panel mounted components.

The overall function of the power supply is to transform and rectify the ac input line voltage into a well regulated, stable, and adjustable dc output. In performing these functions the circuitry can be divided into the following subfunctions.

1. Load Rectifier and Filter
2. Auxiliary Rectifier and Filter
3. Auxiliary Regulator
4. Series Pass Regulator
5. Voltage Compartor
6. Current Compartor
7. Over Voltage "Crowbar" Circuit and Voltage Limiter (V_{LIM}®) Circuit
8. Current Sink Circuit

3.2 CIRCUIT ANALYSIS

The following circuit analysis is referenced to Figure 3-1 and the schematic diagram located at the end of Chapter 5 of this manuel.

3.2.1 Primary Input, Rectifiers and Filter Circuits

The input power is obtained through power transformer T101. Bridge rectifier U101 in model PH or diodes CR109 through CR112 in model PQ provides the load rectification and is applied to the series pass regulators. Capacitors C101 and C102 and resistors R108 and R114 constitutes the load RC filter. Full wave rectifier CR1 and CR2 provides for the auxiliary regulator +15 volt rectification and capacitor C3 provides it's filtering function. Full wave rectifier CR5 and CR6 provides for the +4.7 volt reference rectification and capacitor C6 provides it's filtering function. Full wave rectifier CR7 and CR8 provides the rectification for the three LOCAL MODE LED indicators CR103, CR104 and CR105.

When the front panel ac power switch S101 is placed into it's ON position it's internal neon lamp will illuminate, and ac power is applied to the primary of transformer T101 and regulated dc output power is immediately made available at

the rear panel barrier strip TB101 +V and -V terminals. Overload protection is provided by an input line fuse F101 and an thermal overload switch S102.

3.2.2 Series Pass Regulator Circuit

The dc voltage from the load rectifier is directed through the series pass transistors.

The PQ supplies utilizes two series pass transistors connected in series (Q101 and Q102). Transistor Q101 conduction is controlled by the source regulator Q12 and transistor Q102 conduction is controlled by the voltage comparator output at U2 pin 6 via transistor Q4.

The PH supplies utilizes four series pass transistors in a series-parallel configuration to provide the greater power ratings of the half rack modules. Transistors Q101 and Q102 connected in parallel are controlled by the source regulator Q12 and transistors Q103 and Q104 also connected in parallel are controlled by the voltage comparator output U? pin 6 via transistor Q4.

3.2.3 Auxiliary Regulator Circuit

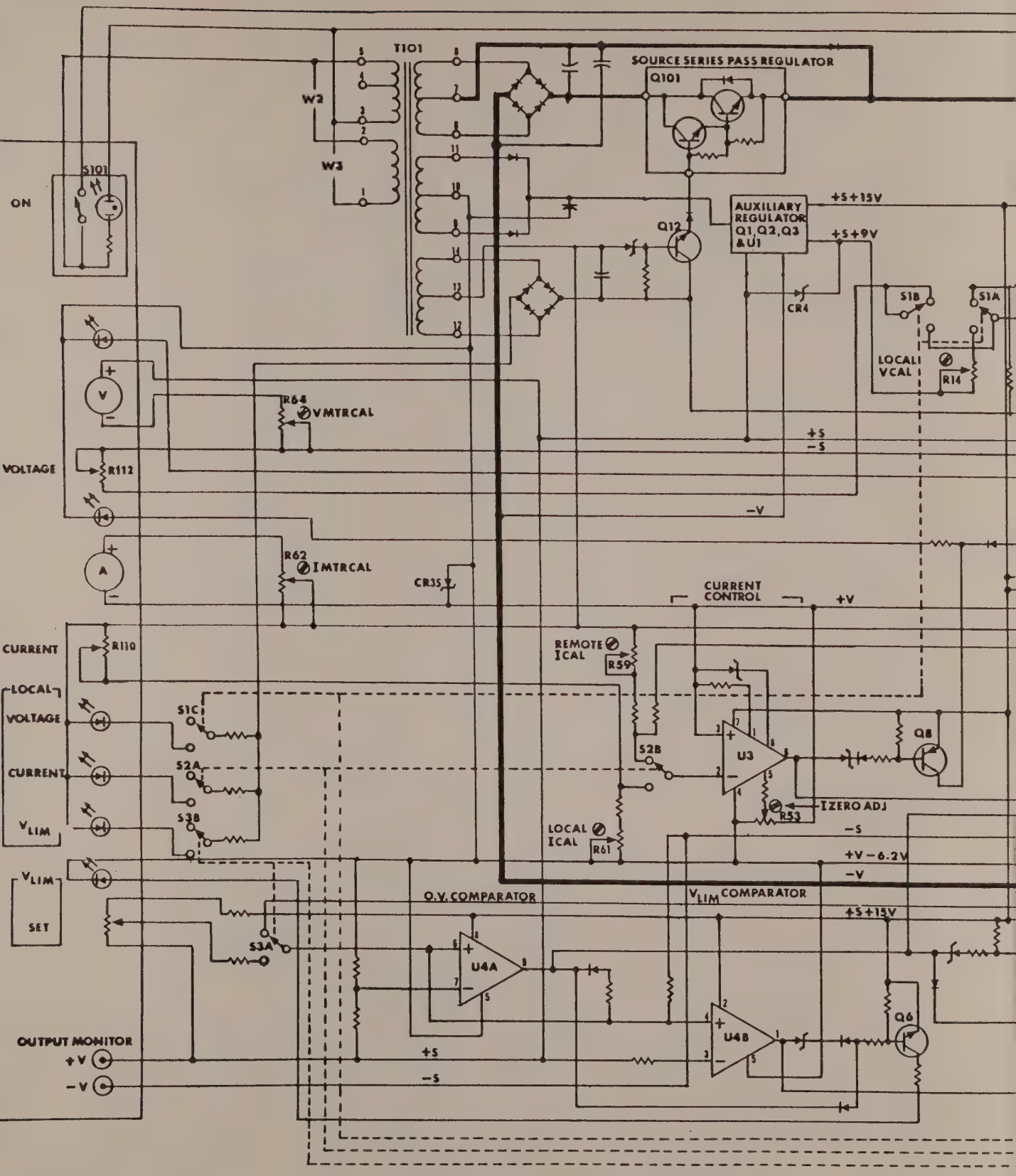
The rectified and filtered voltages from rectifiers CR1 and CR2 and capacitor C3 is applied to the auxiliary series pass transistor Q2 and the constant current source FET Q1. The conduction of Q1 and Q2 is controlled by IC differential amplifier U1. The auxiliary regulator circuit supplies highly stable reference voltages that are referenced to the +S and +V lines. These reference voltages are listed as follows with their associated zener reference diode.

1. +S +9V CR4
2. +S +15V CR3
3. +V -6.2V CR35

3.2.4 Voltage Comparator Circuit

The voltage sensing and comparison is accomplished by IC differential amplifier U2. A sampling of the output voltage as the +S signal is applied to the inverting input of U2 at pin 2. A voltage level that relates to the desired output power supply voltage (set point value) is applied to the non-inverting input of U2 at pin 3. This set point value is set by the front panel VOLTAGE control potentiometer R112 when local operation is selected via switch S1. When remote voltage control is selected the set point value is obtained from the rear panel programming connector J2 pins 10 and L via switch S1.

If the output voltage of the power supply changes due to loading effect, the error (difference between the +S and set point voltage levels) appears as a voltage change at U2 pin 6. This error voltage is then applied to the series pass transistor circuit via emitter follower Q4 as base bias.


T101
W2
W3
SOURCE SERIES PASS REGULATOR
Q101
AUXILIARY REGULATOR Q1,Q2,Q3 &U1
+S+15V
+S+9V
Q12
CR4
S1B
S1A
LOCAL VCAL
R14
ON
S101
R64 VMTRCAL
VOLTAGE
R112
R62 IMTRCAL
CR35
CURRENT CONTROL
+V
CURRENT
R110
REMOTE ICAL
R59
LOCAL
VOLTAGE
CURRENT
VLIM
S1C
S2A
S3B
S2B
U3
Q8
IZERO ADJ
R53
LOCAL ICAL
R61
-S
+V-6.2V
-V
VLIM SET
S3A
O.V. COMPARATOR
U4A
VLIM COMPARATOR
+S+15V
U4B
Q6
OUTPUT MONITOR
+V
-V
+S
-S

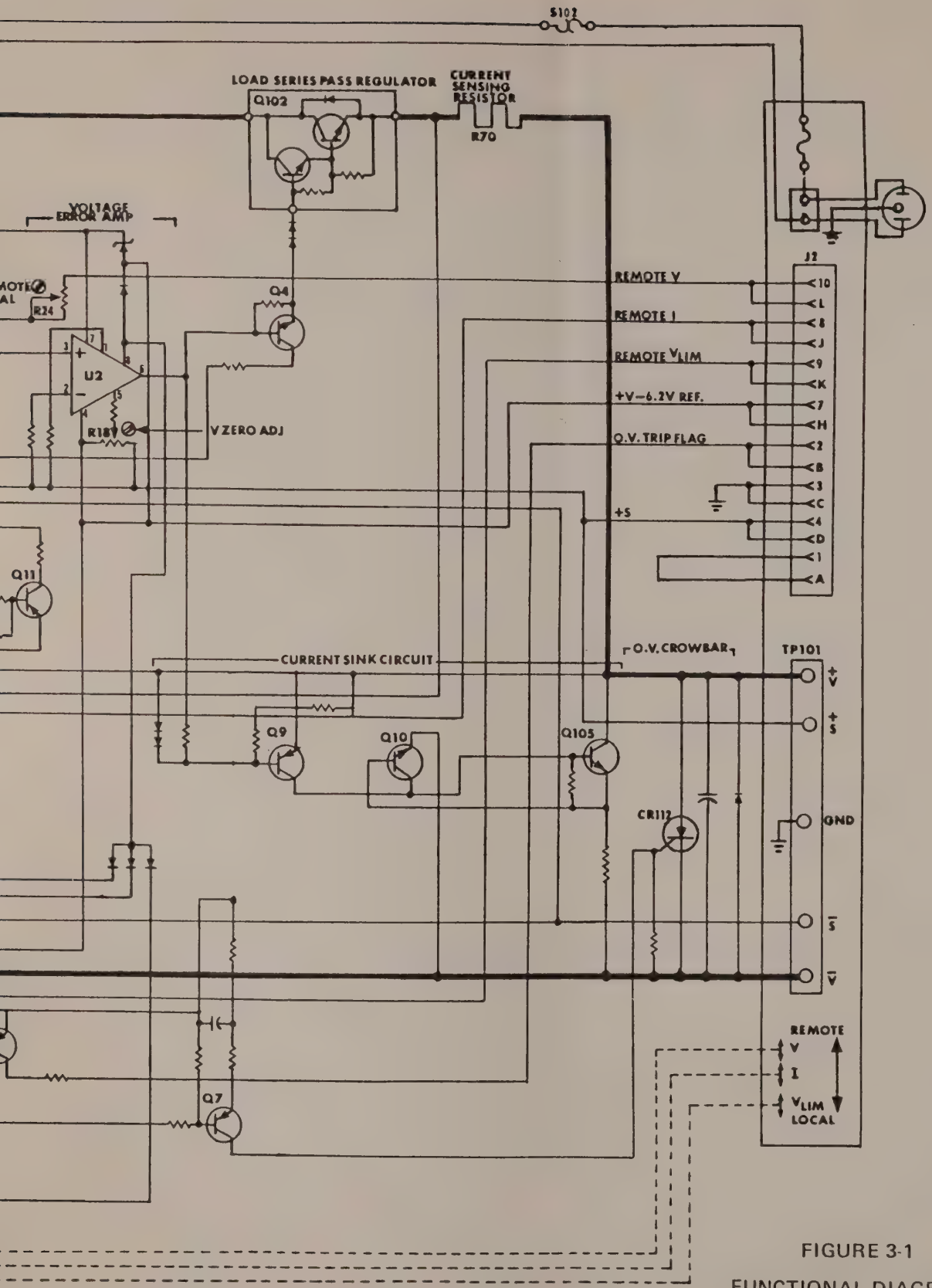


FIGURE 3-1
FUNCTIONAL DIAGRAM

3.2.5 Current Comparator Circuit

The current comparator circuit provides the constant current when in the current mode or current limiting when in the voltage mode.

The current sensing and comparison is accomplished by IC differential amplifier U3. A sampling of the output current is provided by monitoring the voltage drop across the current sensing resistor R70. The output end of resistor R70 is applied to U3 pin 3 as the +V signal.

When local current mode is selected the emitter output of the series pass transistor circuit is monitored via the front panel CURRENT control potentiometer R110 and applied to U3 pin 2. The LOCAL I CAL adjustment potentiometer R61 is connected between the +V -6.2V reference and U3 pin 2 to allow for the calibration of the front panel CURRENT control.

When remote current mode is selected U3 pin 2 receives its current limiting control via switch S2B from the rear panel programming connector J2 pins 8 and J as an 0 to -1 ma current input. The output of the series pass transistor circuit is monitored via the REMOTE I CAL adjustment potentiometer R69 to allow for the calibration of the remote current control scale factor.

The voltage difference developed between U3 pin 2 and 3 is the current error, which is amplified to generate the current control signal at U3 pin 6. The output at U3 pin 6 is applied to U2 pin 8 via diode CR15 which provides a variable clamping action to the voltage comparator U2, which in effect will increase or decrease the conduction of the series pass transistor circuit, thus maintaining a constant voltage across the current sensing resistor R70. When operating in the constant current mode, transistor Q8 is bias into conduction via diode CR31, there by causing the front panel I MODE amber LED indicator to illuminate. When transistor Q8 goes into conduction transistor Q11 is bias off via diode CR38 thus causing the front panel V MODE green LED indicator to extinguish.

The crossover between constant voltage to constant current mode is automatic. The point at which the operating mode automatically changes is a function of variation of the external load and occurs at a critical value of the load resistance $R_L = E_S/I_S$, where E_S is the voltage control setting and I_S is the current control setting.

3.2.6 V_{LIM} and Over Voltage Circuit

The voltage limiting (V_{LIM}) and over voltage (crowbar) protection functions are provided to protect the load or the power supply itself from over voltage due to programming, external voltage or internal malfunctions.

The V_{LIM} threshold can be set at any point from 5% to 109% of the power supplies rated output voltage by the front panel screwdriver adjustment V_{LIM} SET potentiometer R109 when local V_{LIM} is selected by switch S3A, or by a 0 to +10.9V level applied to the remote programming connector J2 pins 9 and 10 when remote V_{LIM} is selected by switch S3A. Switch S3B provides for the illumination of the V_{LIM} green LED CR105 when local V_{LIM} operation is selected. The over voltage crowbar threshold will track the V_{LIM} set point and trigger whenever the voltage across the +V and -V output terminals exceeds the V_{LIM} set point by 1% of the power supplies rated output voltage.

The V_{LIM} sensing is accomplished by IC differential amplifier U4B. A sampling of the output voltage is applied to U4B pin 3 and a 0 to +10V level that relates to the V_{LIM} set point is applied to U4B pin 4. This V_{LIM} set point value is set by the front panel V_{LIM} potentiometer R109 when in the local mode or applied remotely via connector J2 pins 9 and K when remote mode is selected. If the output voltage exceeds the V_{LIM} set value the voltage differential between U4B pins 2 and 3 is sensed at U4B pin 1 as the V_{LIM} control signal. This control signal at U4B pin 1 is applied to the voltage comparator U2 pin 8 via diode CR13 which provides a clamping action to the voltage comparator U2, which in effect will decrease the conduction of the series pass transistor circuit and limit the output voltage to the V_{LIM} set value.

The over voltage sensing is accomplished by IC differential amplifier U4A. A sampling of the output voltage is applied to U4A pin 7 and the V_{LIM} set point value is applied to U4A pin 6. If the output voltage exceeds the V_{LIM} set value by 1% of the rated voltage output a over voltage trip signal will be generated at U4A pin 9. The output at U4A pin 9 is applied via diode CR23 to the base of transistor Q7 which provides the gate drive for the crowbar SCR. The collector of Q7 outputs the SCR trigger via diode CR30 to the gate of SCR CR102 causing it to "fire" thus crowbaring the +V and -V terminals of the power supply. The over voltage trip signal at U4A pin 9 is also applied to transistor Q5 via zener diode CR25. Transistor Q5 outputs the remote O.V. trip flag from it's collector to connector J2 pins 2 and B to signal the remote programming device that the power supply has crowbared due to an over voltage condition.

The front panel V_{LIM} red LED indicator CR106 will illuminate whenever the V_{LIM} set value is exceeded or an over voltage trip condition is present. Transistor Q5 provides the LED drive and is turned on by either the V_{LIM} signal at U4B pin 1 via diode CR27 or the over voltage trip signal at U4A pin 9 via diode CR26.

3.2.7 Current Sink Circuit

The current sink circuit provides for the discharge of the power supplies output capacitors C107 and C108 and any external capacitance related to the load during dynamic programming of the supply.

Transistor Q9 monitors any down voltage programming change at the voltage comparator output U2 pin 6, and transistor Q10 monitors the emitter of the current sink transistor Q105 and its sink resistor R105. The sink circuit will current limit at the values listed below down to an output voltage level of ≈2V. Below 2V the sinking will decrease rapidly.

TABLE 3-1 SINK CURRENT LIMIT VALUES

POWER SUPPLY RATED OUTPUT VOLTAGE	SINK CURRENT LIMIT VALUE
10V	3.5A
20V	2.3A
50V	1.0A
100V	0.35A

Proper operation of the sink circuit can be verified by monitoring the voltage drop across the sink resistor R105 it should be 0.7 volts during the discharge of the capacitance.

Figure 3-2 provides an example of the current sink function of the P-Series PQ10-3 or PH10-10 power supply being down programmed. The time period is determined by the load capacitance.

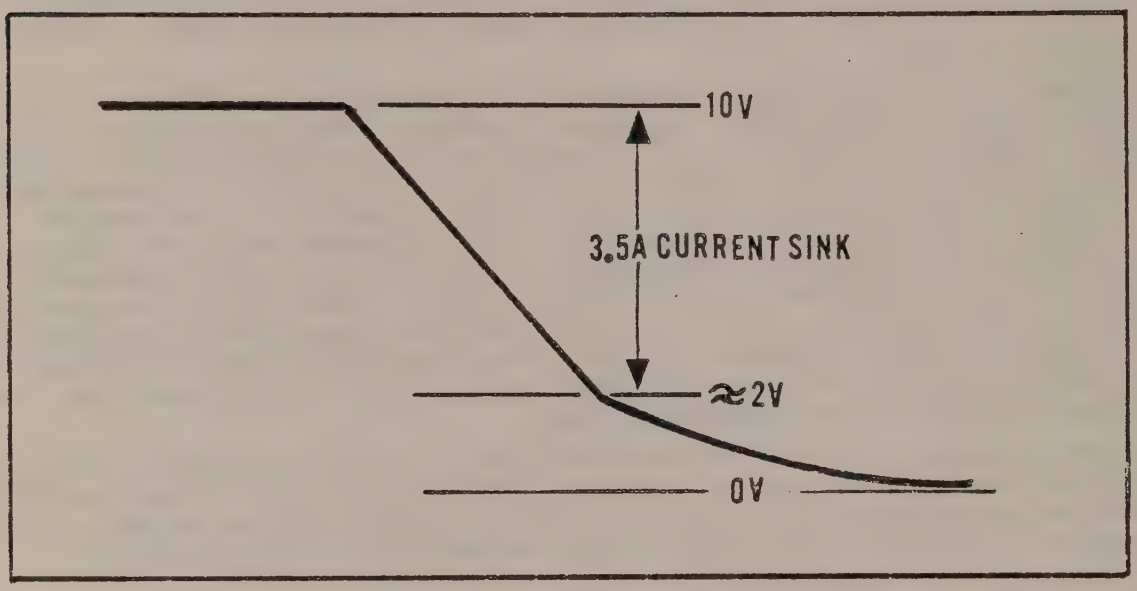


FIGURE 3-2 CURRENT SINK FUNCTION

The step response time into a resistive load is specified at 2 ms, when operating into a capacitive load this step response time will increase due to the current sink circuit. The response time can be calculated by the following equation.

$$\text{Response Time} = \frac{\Delta E\ (C_i + C_e)}{I_l}$$

where: ΔE is the change in voltage

C_i is the supplies internal capacitance (C107 and C108)

C_e is the external load capacitance

I_l is the sink current limit value

the units of measure are in seconds, volts, farads and amperes.

CHAPTER 4
MAINTENANCE AND CALIBRATION

4.1 INTRODUCTION

This chapter provides information on alignment and calibration procedures, routine maintenance, and troubleshooting techniques.

Whenever the Power Supply requires factory service the nearest Systron-Donner representative should be contacted. He can provide field service at your location or arrange factor return if necessary. Address all inquiries on operation, service or application to your nearest service representative or service division. Specify the model and complete serial number in all correspondence.

4.2 TEST EQUIPMENT

Table 4-1 lists the test equipment required for the test and calibration procedures. Alternate test equipment with equivalent characteristics may be used when the recommended types are not available.

TABLE 4-1 RECOMMEND TEST EQUIPMENT

Oscilloscope Tektronic 5000 Series	1 mV/Div. resolution 10 MHz bandwidth
Digital Multimeter Systron-Donner 7004 (Two required)	4÷1/2 digit ±0.1%
Variable Auto-transformer (Variac)	0-140 Vac 200 watts
Control PCB Extender Systron-Donner P/N 065428	
Current Measuring Shunt Resistor	10A capacity 0.1%
Appropriate Load Resistors or Load Bank	
1 kΩ Precision Resistor	1 kΩ 0.1% 1/8 watt
Power Supply Programmer Systron-Donner P1 (or if not available)	
Precision Voltage Source	0 to 10V with a minimum 1 mA current capacity

4.3 TEST AND CALIBRATION PROCEDURES

4.3.1 Prepower Check Procedure

1. Ensure that the shorting links are connected across the +V and +S and the -V and -S terminals on rear panel barrier strip TB101 to allow local sensing and regulation.

2. Ensure that the power supply is wired for the line voltage to be used. Refer to the schematic diagram at the end of Chapter 5 and the following power transformer connection chart.

NOTE

The Power Supply is normally factory wired for 104-127 Vac.

POWER TRANSFORMER PRIMARY CONNECTION CHART

LINE VOLTAGE	FROM	TO	JUMPER(S) INSTALLED
90-110	S101-1	T101-4	W2, W3
104-127	S101-1	T101-5	W2, W3
194-237	S101-1	T101-4	W1
207-253	S101-1	T101-5	W1

3. Ensure that 3A slow-blow fuse is installed in the rear panel fuse holder F101.

4.3.2 Local Mode Operational Test and Calibration Procedure

1. Preset the front panel's VOLTAGE control fully CCW, CURRENT control 3-turns CW and V_{LIM} control full CW. Mechanically zero the VOLTS and AMPERES meters via their front panel adjustment slots.

2. Place the rear panel accessed LOCAL-REMOTE V, I and V_{LIM} switches to their local (down) positions.

3. Apply line power to the power supply via a variac. Connect a DVM across the +S and -S terminals on TB101. Place the front panel power switch to it's ON position and verify that the power switch internal neon lamp illuminates.

4. Slowly run up the variac to the nominal line voltage. The DVM should indicate a zero ($\leq$0.1V) output. If the output voltage starts to come up, immediately run down the variac and clear the fault before continuing.

5. With nominal line voltage input established, measure the voltage across the output of bridge rectifier U101 and verify it as to model as follows:

PQ 10-3	21 Vdc
PQ 20-2	35 Vdc
PQ 50-1	74 Vdc
PQ 100-.5	138 Vdc
PH 10-10	21 Vdc
PH 20-6	35 Vdc
PH 50-3	72 Vdc
PH 100-1.5	138 Vdc

6. Measure the voltage across capacitor C7, verify that it is 15V ±0.6V, with an oscilloscope verify that the PARD is $\leq$0.75 mV p-p.

7. Measure the voltage across zener diode CR35, verify that it is 6.2V ±0.31V.

8. Verify that the LOCAL-VOLTAGE, CURRENT and V_{LIM} LED's are illuminated. Verify that the CONTROL MODE left (green) LED is illuminated.

9. Monitor the voltage between the +S and -S TB101 terminals with a DVM. Rotate the VOLTAGE control fully CW. Adjust potentiometer R14 for a DVM reading of 2% greater than supplies rated output voltage.

10. Rotate the VOLTAGE control CCW to the power supplies rated voltage as indicated on the DVM. Then adjust potentiometer R64 for a full scale reading on the front panel voltmeter.

11. Rotate the VOLTAGE control fully CCW maintaining pressure on it's stop. Then adjust potentiometer R18 for a DVM reading as near to zero volts as possible.

12. Connect an appropriate resistive load across the rear panel TB101 +V and -V terminals with a current monitoring shunt resistor in series with the load.

13. Rotate the CURRENT control fully CW.

14. Slowly load the power supply to it's full rated voltage and current, while monitoring the current with a DVM connected across the shunt resistor and the voltage with a DVM connected across the +S and -S terminals. Adjust potentiometer R61 as necessary to achieve the full rated voltage and current.

15. On the PH half rack supplies only measure the voltage across resistors R101 and R102, then resistors R103 and R104. The current through each pair of resistors should be within 10%.

16. Adjust potentiometer R62 for a full scale reading on the front panel ampere meter.

17. Increase the load for a current output of 102% of the power supply's rated output.

18. Carefully adjust potentiometer R61 to achieve a 102% current limit of the rated output. Verify that the front panel current CONTROL MODE LED (amber) indicator illuminated at approximately the current limit threshold level.

19. Rotate the CURRENT control fully CCW maintaining pressure on it's stop. Then adjust potentiometer R53 for as close to zero current as possible.

20. Reduce the loading to achieve a 100% rated voltage output, without current limiting. Verify that the CONTROL MODE green LED is illuminated and amber LED is extinguished.

21. Rotate the front panel V_{LIM} control slowly CCW while observing the output voltage on a DVM and the front panel V_{LIM} (red) LED indicator. The V_{LIM} LED indicator should illuminate after approximately 3-1/2 turns of the V_{LIM} control, and at the same point the output voltage should start decreasing. Continue to rotate the V_{LIM} control CCW and verify that output voltage decreases to approximately zero volts when the V_{LIM} control is fully CCW. Return the V_{LIM} control to its fully CW position, and verify that the supply outputs 100% rated voltage.

4.3.3 Remote Mode Operational Test and Calibration Procedure

The following procedure utilizes a precision voltage source as an programmer device. If the Systron-Donner P-1 Programmer is available the appropriate remote

stimulus may be generated and applied by the P-1 to a resolution of 10 mV.

1. Remove power from the power supply under test. Place the rear panel accessed LOCAL-REMOTE V switch (S1) to it's REMOTE (up) position. Ensure that the LOCAL-REMOTE I (S2) and V_{LIM} (S3) switches are in their local (down) positions.

2. Apply 10.00V from the voltage source to the power supply's remote programming connector J2, plus to pin 10 and minus to pin 4.

3. Apply power to the power supply under test and allow 5 minutes for stabilization.

4. With the DVM verify that the voltage applied across pins 10 and 4 of J2 is exactly +10.00V, if not adjust voltage source as required.

5. Place the DVM across the +S and -S terminals of TB101 and adjust potentiometer R24 for DVM reading of exactly 100% of the power supplies rated output voltage.

6. Remove the applied 10 volts from J2 pin 10 and 4. Place a short across J2 pins 10 and 4 then adjust potentiometer R18 for DVM reading of 000.00 volts. Remove the short across J2 pins 10 and 4, reapply the 10V from the voltage source then repeat steps 4 and 5.

7. Remove power from the power supply under test. Place the rear panel accessed LOCAL-REMOTE I switch (S2) to it's remote (up) position. Ensure that the LOCAL-REMOTE V (S1) and V_{LIM} (S3) switches are in their local (down) positions.

8. Apply 2.0V from the voltage source via a series 1 k Ω 0.1% resistor to the power supply's remote programming connector J2 plus to pin 8 and minus to pin 4. With a DVM measure the voltage drop across the 1 k Ω precision resistor and adjust the voltage source for exactly 1.00 volts (1 mA current flow).

9. Connect an appropriate resistive load across the rear panel TB101 +V and -V terminals with a current monitoring shunt resistor in series with the load.

10. Apply power to the power supply under test and allow 5 minutes for stabilization.

11. Slowly load the power supply to it's full rated voltage and current, while monitoring the current with a DVM connected across the load shunt resistor and the voltage with a DVM connected across the +S and -S terminals, by use of the front panel VOLTAGE control.

12. Carefully adjust potentiometer R59 to achieve a 100% current limit of the rated output. Verify that the front panel current CONTROL MODE LED (amber) indicator illuminated at approximately the current limit threshold level.

13. Remove the voltage source and the 1 k Ω resistor configured in step 8. Place a short across J2 pins 8 and 4. Then adjust potentiometer R53 for as close to zero current as possible by monitoring the voltage drop across the series shunt resistor.

14. Remove power from the power supply and disconnect the resistive load and current monitoring resistor connected in step 9.

15. Place the rear panel accessed LOCAL-REMOTE V_{LIM} switch to it's REMOTE (up) position. Ensure that the LOCAL-REMOTE V (S1) and the I(S2) switches are in their local (down) positions. Rotate the front panel VOLTAGE control fully CW. Apply 10.00V from the voltage source to the power supply's remote programming connector J2, plus to pin 9 and minus to pin 4.

16. Apply power to the power supply and allow 5 minutes for stabilization. With a DVM measure the voltage across J2 pins 9 and 4, then measure and confirm that the output voltage on the +S and -S TB101 terminals is the same scale percentage ±.5% (10V:100%) as the voltage applied to J2 pins 9 and 4. Verify that the front panel V_{LIM} LED (red) is illuminated indicating V_{LIM} mode of operation.

4.3.4 Overvoltage Crowbar Circuitry Test

The crowbar circuitry consists of an SCR (CR102) placed across the +V and -V output terminals of the power supply. A bias (SCR gating level) that relates to the V_{LIM} setting +1% of the rated output voltage is developed by the crowbar circuitry and applied to the SCR gate. Under most normal operating conditions the V_{LIM} circuitry will limit the power supply's output voltage to the V_{LIM} setting, thus preventing the triggering of the SCR. However, if an external voltage is applied across the power supply's output that is 1% greater than the V_{LIM} setting or if an internal malfunction should occur that will raise the output above the V_{LIM} setting the crowbar SCR will trigger thus shorting the power supply's output.

The most practical method to test the operation of the crowbar circuitry is to apply a voltage that is 1% greater than the V_{LIM} setting to the +V and -V output terminals with an external power supply. The P-Series power supply's will sink current at various amounts depending on it's rated voltage output, as listed below:

Rated Output Voltage	Sink Current
10V	3.5A
20V	2.3A
50V	1.0A
100V	350 mA

Thus the external power supply must be able to supply greater current than the sink circuitry will accept, but must be limited to less than 10 amperes continuous current to prevent the SCR from damage after it triggers.

4.3.5 Current Sink Test Procedure

The current sink circuitry will sink current at various amounts depending on it's rated voltage output, as listed as follows:

Rated Output Voltage	Sink Current
10V	3.5A
20V	2.3A
50V	1.0A
100V	350 mA

This current sinking feature is provided to discharge the internal output capacitor's C107 and C108 and any external capacity connected across the +V and -V output terminals, thus promoting rapid down voltage programming.

To verify the proper operation of the current sink circuitry perform the following steps.

1. Connect a 100 μfd capacitor having a working voltage rating of the power supply being tested across the +V and -V output terminals.

2. Program the power supply under test to 100% of its voltage rating.

3. Monitor the voltage change across resistor R105 with an oscilloscope while rapidly programming the power supply to 0 volt output.

4. Verify that ≈ 0.7 V was observed across resistor R105 during the discharge of the capacity.

NOTE

The sink current should limit at the value listed above ±10% down to an output voltage of 2V. Below 2V the sink current will decrease rapidly.

4.3.6 Power Supply Performance Tests

The following test procedure is provided to verify the Performance Specifications of the power supply given in Chapter 1 Table 1-3 of this manual.

1. Configure the Power Supply for voltage control mode performance test as depicted in figure 4-1.

2. Load the Power Supply to its rated output voltage and current, Ensure that the Power Supply is operating in its voltage control mode by verifying that the left (amber) control mode LED indicator is illuminated.

3. Vary the line voltage with the variac from 104 to 127 Vac and note the output voltage change on the DVM. The source effect should be less than .001% of the rated voltage.

4. Establish 115 Vac input line voltage with the variac, switch back and forth from full rated load to no load operation by opening and closing the load switch, while observing the output voltage change on the DVM. The load effect should be less than .002% of the rated voltage.

5. Apply rated load to the Power Supply. With an differential input oscilloscope measure the PARD (ripple and noise) across the power supply's output, it should be less than 3 mV p-p.

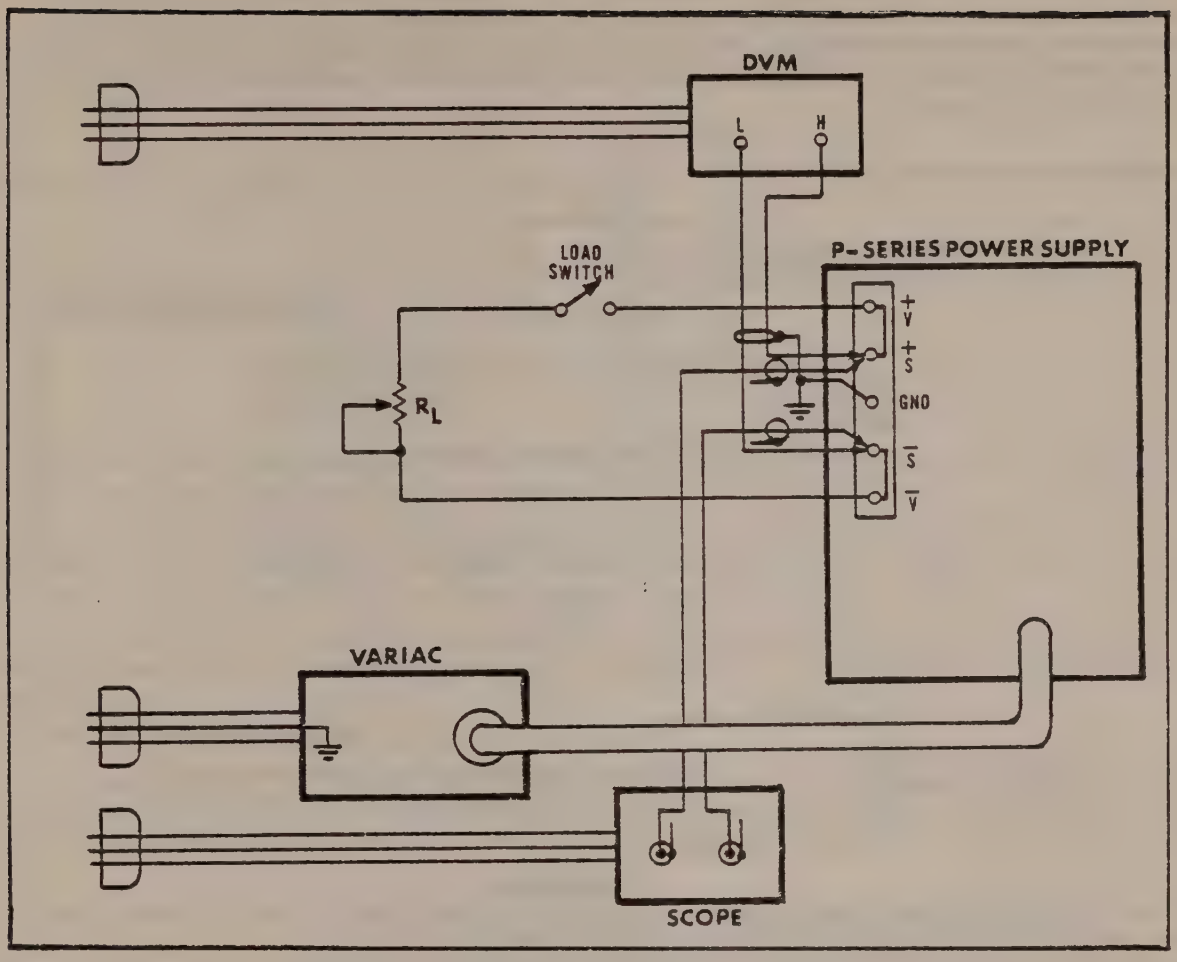


FIGURE 4-1 VOLTAGE MODE TEST CONFIGURATION

6. Configure the Power Supply for current control mode performance test as depicted in Figure 4-2.

7. Load the Power Supply to it's rated output voltage and current. Then adjust the front panel CURRENT control to place the Power Supply into it's current control mode, verify that the right (green) control mode LED illuminates.

8. Vary the line voltage with the variac from 104 to 127 Vac and note the voltage change on the DVM connected across the R_S resistor. Calculate the equivalent change of current resulting from the measured voltage change. The source effect should be less than .005% or 200 µA, whichever is greater.

9. Establish 115 Vac input line voltage with the variac. Switch from load to short by opening and closing the load shorting switch and note the voltage change across the R_S resistor. Calculate the equivalent current resulting from the measured voltage change. The load effect should be less than .05% of the rated current or 1 mA whichever is greater +3 mA.

10. With the Power Supply operating in it current control mode at full rating, measure the PARD (ripple and noise) across the R_S resistor with an differential input oscilloscope. Calculate the equivalent current from the p-p voltage measurement it should be less than .15% of the rated current or 3 mA whichever is greater.

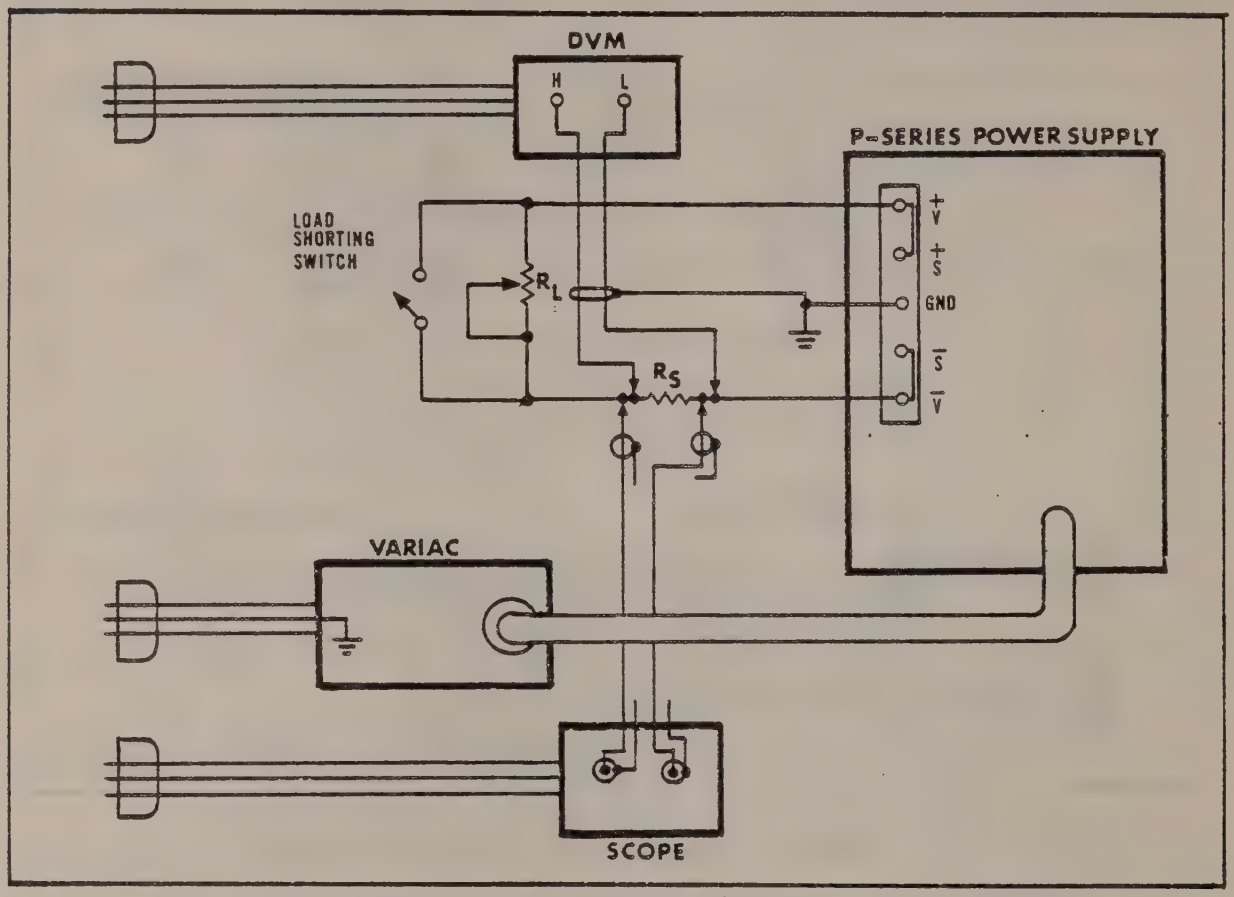


FIGURE 4-2 VOLTAGE MODE TEST CONFIGURATION

4.4 POWER SUPPLY TROUBLESHOOTING

If a malfunction is indicated the following procedures should be performed to isolate the fault.

4.4.1 Loads and Interconnections

To Ensure that the malfunction is not due to any external influence, remove the Power Supply from the system and perform the following procedure.

1. Disconnect all interconnects and loads to which the Power Supply is normally integrated with.

2. Install shorting links on the rear panel TB101 barrier strip between +V and +S and -V and -S terminals. Ensure that the shorting link connections are securely made to prevent any deterioration of supply regulation.

3. Connect a resistive load across the +V and -V terminals having the proper ohmic value and wattage rating to provide a maximum rated load to the Power Supply.

MODEL	LOAD RESISTOR	
PQ 10-3	3.3Ω	30W
PQ 20-2	10Ω	40W
PQ 50-1	50Ω	50W
PQ 100-.5	2Ω	50W
PH 10-10	1Ω	100W
PH 20-6	3.33Ω	120W
PH 50-3	16.67Ω	150W
PH 100-1.5	66.67Ω	150W

Ensure that the load connections are securely made and that the wiring used is of sufficient gauge to carry the current.

4. Apply nominal ac line power and check for normal operation i.e., rated output and regulation. Proper operation at this time would indicate that any malfunction previously encountered, was external in nature.

5. Check all interconnects, loads, remote programming devices, shielding and grounding that interfaced with the Power Supply for any faults or application errors.

4.4.2 Power Supply Fault Isolation

If the malfunction is determined to be internal to the Power Supply first perform the Test and Calibration Procedures located in paragraph 4.3, to ensure that the malfunction does actually exist, and if so cannot be corrected by calibration.

A good understanding of the principles of operation of the Power Supply is essential to efficient troubleshooting techniques. For this reason, it is recommended that Chapter 3 of this manual be reviewed before attempting to troubleshoot the unit.

Before proceeding with the troubleshooting procedure check for obvious troubles such as an open fuse, defective power cord, out of tolerance line power. Next visually inspect the Power Supply's mechanical integrity for such items as loose plug-in Control PCB assembly and loose or displaced component parts and wiring that could cause shorts or opens. Then check for mechanical and thermal damage, i.e., broken, discolored or charred component parts.

If the source of the trouble cannot be detected by visual inspection or the malfunction corrected by performing the performance and calibration procedures, then proceed with the following steps.

1. Configure the Power Supply per paragraph 4.4.1 steps 2 and 3.

2. Verify that the rear panel accessed LOCAL-REMOTE V, I and V_{LIM} switches are placed in their LOCAL (down) positions.

3. Apply power and rotate the front panel VOLTAGE and CURRENT controls fully CW.

4. Using a DVM or a voltmeter having an impedance of 50 kΩ/V check the voltages at test points or across the components listed in Table 4-2.

5. If voltage checks show no noticeable deviations from the prescribed values in Table 4-2 disconnect ac power and proceed with a point-to-point resistance check.

6. If the problem is of an intermittent nature, dynamic changes where noted when making dc voltage checks or high ripple is suspected, the use of an oscilloscope is indicated.

TABLE 4-2 P-SERIES TEST VOLTAGES

Test Point or Component -lead of C102 to + lead of C101	Function	VOLTAGE (Vdc)							
		PQ10-3	PQ20-2	PQ50-1	PQ100-.5	PH10-10	PH20-6	PH50-3	PH100-1.5
	Main Output Filter	≈21	≈35	≈74	≈138	≈21	≈35	≈74	≈138
C3	Aux. Reg. Filter	≈30	→	→	→	→	→	→	≈ 30
CR3	Aux. Ref. Zener	5.6 ± .3	→	→	→	→	→	→	5.6 ± .3
CR4	+S +9V Ref. Zener	9 ± .4	→	→	→	→	→	→	9 ± .4
CR35	+V -6.2V Ref. Zener	6.2 ± .3	→	→	→	→	→	→	6.2 ± .3
C7	+S +15V Reference	15 ± .6	→	→	→	→	→	→	15 ± .6

Note: All voltage measurements are normal power supply operation, 115V nominal ac line input, and full rated output voltage and current.

4.5 INTEGRATED CIRCUITS COMPONENT DATA SHEETS

The following two IC data sheets are provided to give the service technician pinning information, schematic equivalents and detailed characteristics that are unique to the IC devices.

LM201A
LM301A

S-D P/N 037913
S-D P/N 025745

general description

The LM101 series are general purpose operational amplifiers which feature improved performance over industry standards like the LM709. Advanced processing techniques make possible an order of magnitude reduction in input currents, and a redesign of the biasing circuitry reduces the temperature drift of input current. Improved specifications include:

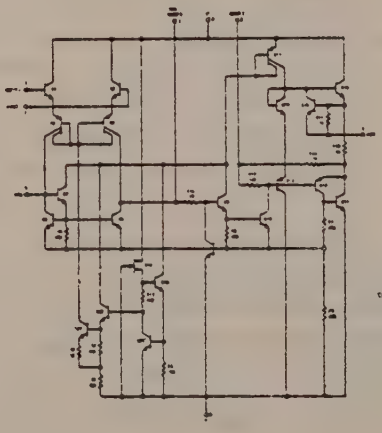
- Offset voltage 3 mV maximum over temperature (LM101A/LM201A)
- Input current 100 nA maximum over temperature (LM101A/LM201A)
- Offset current 20 nA maximum over temperature (LM101A/LM201A)
- Guaranteed drift characteristics
- Offsets guaranteed over entire common mode and supply voltage ranges
- Slew rate of 10V/μs as a summing amplifier

This amplifier offers many features which make its application nearly foolproof: overload protection on the input and output, no latch-up when the common mode range is exceeded, freedom from oscillations and compensation with a single 30 pF capacitor. It has advantages over internally compensated amplifiers in that the frequency compensation can be tailored to the particular application. For example, in low frequency circuits it can be overcompensated for increased stability margin. Or the compensation can be optimized to give more than a factor of ten improvement in high frequency performance for most applications.

The LM101A series offers the features of the LM101, which makes its application nearly foolproof. In addition, the device provides better accuracy and lower noise in high impedance circuitry. The low input currents also make it particularly well suited for long interval integrators or timers, sample and hold circuits and low frequency waveform generators. Further, replacing circuits where matched transistor pairs buffer the inputs of conventional IC op amps, it can give lower offset voltage and drift at a lower cost.

The LM101/LM101A is guaranteed over a temperature range of −55°C to +125°C, the LM201A from −25°C to +85°C, and the LM201/LM301A from 0°C to +70°C.

schematic** and connection diagrams Top Views

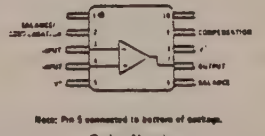


Metal Can Package

Note: Pin 4 connected to case.

Order Number LM101H, LM201H, LM101AH, LM201AH or LM301AH
See Package 11

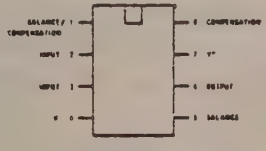
Flat Package



Note: Pin 5 connected to bottom of package.

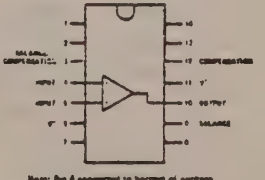
Order Number LM101F, LM201F, LM101AF or LM201AF
See Package 3

Dual-In-Line Package



Order Number LM201J or LM301AJ
See Package 15
Order Number LM301AN
See Package 20

Dual-In-Line Package



Note: Pin 4 connected to bottom of package.

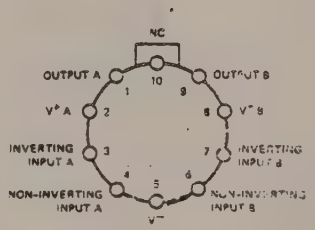
Order Number LM101AD or LM201AD
See Package 28
Order Number LM101AJ-14, LM201AJ-14 LM301AJ, LM101J-14 or LM201J-14
See Package 16

**Pin connections shown are for metal can.

747HC S-D P/N 103708

GENERAL DESCRIPTION — The μA747 is a pair of high performance monolithic Operational Amplifiers constructed using the Fairchild Planar* epitaxial process. They are intended for a wide range of analog applications where board space or weight are important. High common mode voltage range and absence of "latch-up" make the μA747 ideal for use as a voltage follower. The high gain and wide range of operating voltage provides superior performance in integrator, summing amplifier, and general feedback applications. The μA747 is short-circuit protected and requires no external components for frequency compensation. The internal 6 dB/octave roll-off insures stability in closed loop applications. For single amplifier performance, see μA741 data sheet.

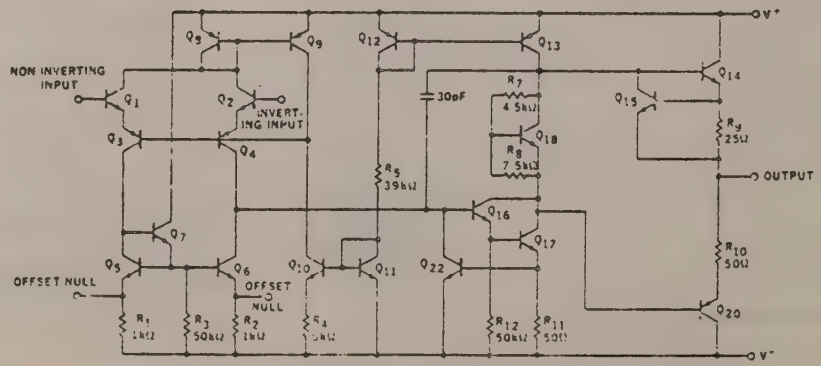
10-LEAD METAL CAN
(TOP VIEW)
PACKAGE OUTLINE 5F



ORDER INFORMATION

TYPE	PART NO.
747	747HM
747C	747HC

EQUIVALENT CIRCUIT (Each Side)



CHAPTER 5
PARTS LIST

5.1 INTRODUCTION

This chapter contains parts list for each assembly in the PH-Series Power Supply. Chapter 6 contains the related schematic indicating circuit location for the respective parts. Ordering information is included and should be used when purchasing parts from the factory. Explanation of the column listings and Table 5-1 Manufacturers Code-To-Name Index are also included.

5.2 PART ORDERING INFORMATION

To order a part from the Replaceable Parts List, state the Systron-Donner part number, indicate the quantity required and address the order to the nearest Systron-Donner Sales or Service Center.

To order a part not listed in the parts list, state the instrument model number, instrument serial number, the description and function of the part, and the number of parts required. Address the order to your nearest Systron-Donner Sales or Service Center.

5.3 PARTS LIST

Table 5-1 gives the code-to-name information for the manufacturers listed in the Replaceable Parts Lists. The replacement parts are listed, when appropriate, in reference designator part number order.

Each column in the parts list provides specified information relating to the listed parts as follows:

(1) ITEM: Numerics assigned to the respective Assemblies. Numbers in this column are used in the USED ON column.

(2) REF: Reference designators as assigned on the respective schematics are listed in this column. Reference designators are listed in alphanumeric sequence.

(3) USED ON: Numbers assigned in this column are derived from the numeric code number (ITEM column) used to identify the related assemblies and or subassemblies of the final product.

(4) COMPONENT DESCRIPTION: Components, assemblies etc, names and specifications provided in this column include; value, tolerance, wattage rating, working voltage, construction, etc.

(5) MFR'S CODE: H4-2 Federal Supply Code numbers are listed in this column to identify the component manufacturer. A Manufacturers Index, code-to-name, is provided in this chapter for cross-reference.

(6) MANUFACTURER'S PART NUMBER: True manufacturer part numbers are listed in this column.

(7) SD STOCK NUMBER: The Systron-Donner Part Number for the component is listed in this column.

(8) T/Q (Total Quantity): This quantity, appearing after an entry, indicates the number of times the component is used in the instrument. The total quantity for each part is given only once at the first appearance of the part number on the list; except for hardware, in which case, the T/Q relates to the used on code item only.

TABLE 5-1 MANUFACTURER'S CODE-TO-NAME INDEX

Code	Name & Address
00853	Sangamo Electric Co. So. Carolina Div. P.O. Box 128 Pickens, SC 29671
01121	Allen-Bradley Co. 1201 So. 2nd St. Milwaukee, WI 53204
03508	General Electric Co. Semiconductor Prodects Dept. Electronics Park Syracuse, NY 13201
03877	Transitron Electronic Corp. 168-186 Albion St. Wakefield, MA 01880
04713	Motorola Semiconductor Inc. 5005 E. McDowell Rd. Phoenix, AZ 85008
05574	Viking Industries Inc. 21001 Nordhoff Chatsworth, CA 91311
06383	Panduit Corp. 17391 Ridgeland Tinley Park, IL 60477
06540	Amatom Electronic Hardware Division of Mite Corp. 81 Rockdale Ave. New Rochelle, MY 10806
06776	Robinson Nugent Inc. P.O. Box 470 New Albany, IN 47150
06915	Richco Plastic Co. 5825 N. Tripp Ave. Chicago, IL 60646
07263	Fairchild Corp. Semiconductor Division 313 Frontage Road Mountain View, CA 94040
08289	Blinn Delbert Co. Inc., The P.O. Box 2007 1678 Mission Blvd. Pomona, CA 91766
08524	Detsch Fastener Corp. P.O. Box 92925 7001 West Imperial Hwy. Los Angeles, CA 90045
08547	Wallace R.G. Co. Inc. 2301 E. Del Amo Blvd. Compton, CA 90220
11534	Duncan Electronics Inc. 2865 Fairview Rd. Costa Mesa, CA 92626
12136	Philadelphia Handle Co. Inc. 1643 Haddon Ave. Camden, NJ 08103
12406	Elpac Inc. 18651 Von Karman Ave. Irvine, CA 92664
12697	Clarostat Mfg. Co Inc. Lower Washington St. Dover, NH 03820
14604	Elmwood Sensors Inc. 1655 Elmwood ave. Cranston, RI 02907
14752	Electro Cube Inc. 1710 So. Del Mar Ave. San Gabriel, CA 91776
15915	Tepro of Florida Inc. 2608 Enterprise Rd. Dunedin, FL 33528
16299	Corning Glass Works Electronic Components Div. 3900 Electronics Drive Raleigh, NC 27604

TABLE 5-1 MANUFACTURER'S CODE-TO-NAME INDEX (Con't)

Code	Name & Address
16758	Delco Radio Division of General Motors Corp. Kokomo, IN
17117	Electronic Molding Corp. 96 Mill St. Woonsocket, RI 02895
19701	Mipco/Electra Inc. Electra Division P.O. Box 760 Mineral Wells, TX 76067
21604	Buckeye Stamping Co. 555 Marion Rd. Columbus, OH 43207
23880	Stanford Applied Engineering Inc 340 Martin Ave Santa Clara, CA 95050
25088	Siemens Corp. 186 Wood Ave. So. Iselin, NJ 08830
27014	National Demiconductor Corp. 2950 San Ysidro Way Santa Clara, CA 95051
27556	IMB Electronic Prod, Inc. 15401-E Carmenita Rd. Santa Fe Springs, CA 90670
28520	Heyman Mfg. Co. 147 N. Michigan Ave. Kenilworth, NJ 07033
32997	Bourns Inc. Trimpot Products Division 1200 Columbia Ave Riverside, CA 92507
50522	Monsanto Co. Electronic Special Products 10131 Bubb Rd. Cupertino, CA 95014
52542	Systron-Donner Corp. Instrument Division 10 Systron Drive Concord, CA 94518
52763	Stettner-Trush Inc. 67 Albany St. Cazenovia, NY
55210	Gettig Engineering & Mfg. P.O. Box 85, off route 45 Spring Mill, PA 16875
56289	Sprague Electronic Co. North Adams, MA 01247
57771	E.B. Stimpson Co. Bayport, NY 11705
70903	Belden Corp. 415 So. Kilpatrick Chicago, IL 60644
71400	Bussmann Mfg. Div. of McGraw-Edison Co. 2536 W. University St St. Louis, MO 63017
71590	Globe-Union Inc. Centralab Electronics Div 5757 No. Green Bay ave Milwaukee, WI 53201
71785	TRW Electronic Components Cinch Connector Operations 1401 Morse Ave Elk Grove Village, IL 60007
72136	Electro Motive Mfg. Co. Inc. South Park & John Sts Willimantic, CT 06226
72982	Gulton Industries Inc. Gudeman Div 340 W. Huron St Chicago, IL 60610

TABLE 5-1 MANUFACTURER'S CODE-TO-NAME INDEX (Con't)

Code	Name & Address
73138	Beckman Instruments Inc. Helipot Div 2500 Harbor Blvd Fullerton, CA 92634
73559	Carling Electric Inc. 505 New Park Ave. West Hartford, CT 06110
74970	E.F. Johnson Co. 299 - 10th Ave. S.W. Waseca, MN 56093
75382	Kulka Electric Corp. 633-643 S. Fulton Ave. Mt. Vernon, NY 10550
75915	Littlefuse Inc. 800 E. Northwest Hwy Des Plaines, IL 60016
78189	Illinois Tool Works Inc. Shakeproof Div St. Charles Rd. Elgin, IL 60120
79727	C-W Industries P.O. Box 96 550 Davisville Rd. Warminister, PA 18964
79963	Zierick Mfg. Co. Radio Circle Mt. Kisco, NY 10549
80103	Lambda Electronics Corp. 515 Broad Hollow Rd. Melville, NY 11746
80294	Bourns Inc. Instrument Div 6135 Magnolia Ave Riverside, CA 92506
81349	Mil Std
81483	International Rectifier Corp. 9220 Sunset Blvd Los Angeles, CA 90069
83330	Smith, Herman H. Inc. 812 Snediker Ave Brooklyn, NY 11207
83777	E-Systems Inc. Memcor Div. 41 E. Park Dr. Huntington, IN 46750
86797	Rogan Corp. 3455 Woodhead Dr. Northbrook, IL 60062
88245	Litton Systems Inc. Useco Div 13536 Saticoy St. Van Nuys, CA 91409
91418	Radio Materials Co. 4242 W. Bryn Mawr Chicago, IL 60646
91637	Dale Electronics Inc. P.O. Box 609 Columbus, NB 68601
94222	Southco Inc. Lester, PA 19113
95146	Alco Electronic Prod. Inc. P.O. Box 1348 Lawrence, MA 01842
96906	Mil Std
98410	Etc Inc. 990 E. 67th St. Cleveland, OH 44103
99392	S T M Corp. 2904 Chapman St. Oakland, CA 94601
99515	ITT Jennings Monrovia Plant Div of ITT Jennings 1960 Walker Ave. Monrovia, CA 91016

REPLACEABLE PARTS LIST

TITLE PH SERIES FINAL ASSEMBLY 065429A

ITEM	REF	USED ON	COMPONENT DESCRIPTION	MFR'S CODE	MANUFACTURER'S PART NUMBER	SD STOCK NUMBER	T/Q
		1-4	ASSEMBLY, Cover	52542	06526701	06525601	Ref
1		1-4	COVER, Top	52542	065267	065267	1
2		1-4	COVER, Handle	12136	382-394SS	117497	2
3		1-4	HANDLE	52542	33570-3	33570-3	1
4		1-4	WASHER, FLAT	96906	MS15795-808	100648	2
5		1-4	NUT, Hex 10-32	96906	MS35650-104	100709	2
6		1-4	WASHER, Split #10	96906	MS35338-138	100714	2
7		1-4	SCREW, PHMS 6-32X3/8	96906	MS51957-28	10063206	8
		1-4	KIT, Input Connector	52542	06542802	06542802	Ref
8		1-4	CONNECTOR	71785	S-306-AB	101253	1
9		1-4	BOARD, Extender	52542	065416	065416	1
10		1-4	ADAPTER, Bracket	52542	065403	065403	1
11		1-4	LATCH, Snap	94222	A3-10-310-12	103858	1
12		1-4	HOOD, Connector	05574	036-0097-003	117510	1
13		1-4	COVER, Protective	52542	065427	065427	1
14		1-4	SCREW, PHMS 6-32X5/16	96906	MS51957-27	10063205	2
15		1-4	WASHER, Split #6	96906	MS35338-136	100712	2
16		1-4	WASHER, Flat #6	96906	MS15795-805	100704	2

1=PH10-10 2=PH20-6 3=PH50-3 4=PH100-1.5

REPLACEABLE PARTS LIST

TITLE PH SERIES CHASSIS ASSEMBLY

ITEM	REF	USED ON	COMPONENT DESCRIPTION	MFR'S CODE	MANUFACTURER'S PART NUMBER	SD STOCK NUMBER	T/Q
		1	ASSEMBLY, Chassis	52542	06538301	06538301	1
		2	ASSEMBLY, Chassis	52542	06538302	06538302	1
		3	ASSEMBLY, Chassis	52542	06538303	06538303	1
		4	ASSEMBLY, Chassis	52542	06538304	06538304	1
1		1-4	CHASSIS	52542	065383	065383	1
2		1-4	FOOT, Rubber	21604	MP4008-1	840192	4
3		1	ASSEMBLY, Front Panel	52542	06538101	06538101	Ref
3		2	ASSEMBLY, Front Panel	52542	06538102	06538102	Ref
3		3	ASSEMBLY, Front Panel	52542	06538103	06538103	Ref
3		4	ASSEMBLY, Front Panel	52542	06538104	06538104	Ref
4		1	ASSEMBLY, Rear Panel	52542	06538201	06538201	Ref
4		2	ASSEMBLY, Rear Panel	52542	06538202	06538202	Ref
4		3	ASSEMBLY, Rear Panel	52542	06538203	06538203	Ref
4		4	ASSEMBLY, Rear Panel	52542	06538204	06538204	Ref
5		1	ASSEMBLY, PC Board	52542	06536701	06536701	Ref
5		2	ASSEMBLY, PC Board	52542	06536702	06536702	Ref
5		3	ASSEMBLY, PC Board	52542	06536703	06536703	Ref
5		4	ASSEMBLY, PC Board	52542	06536704	06536704	Ref
6	C101, C102	1	CAPACITOR, E1 Can 86000µF 15V		EMC863DH15S	117647	2
6	C101, C102	2	CAPACITOR, E1 Can 50000µF 25V		EMC503EH25S	117648	2
6	C101, C102	3	CAPACITOR 23800µF 40V	52542	820378	820378	2
6	C101, C102	4	CAPACITOR 6400µF 100V	52542	820284	820284	2
7		1-4	ASSEMBLY, Heat Sink	52542	06541501	06541501	Ref
8		1,2	BRACKET, Capacitor 3"	56289	4586-2	117149	2
8		3,4	BRACKET, Capacitor 2 1/2			T900060	2
9		1-4	BARRIER STRIP	75382	699CKT53-2	117474	1
10	R108, R114	1	RESISTOR, CC 390Ω 5% 1W	01121	GB3915	101532	2
10	R108, R114	2	RESISTOR, CC 1K 5% 1W	01121	GB1035	101635	2

1=PH10-10 2=PH20-6 3=PH50-3 4=PH100-1.5

REPLACEABLE PARTS LIST

TITLE PH SERIES CHASSIS ASSEMBLY

ITEM	REF	USED ON	COMPONENT DESCRIPTION	MFR'S CODE	MANUFACTURER'S PART NUMBER	SD STOCK NUMBER	T/Q
10	R108, R114	3	RESISTOR, CC 4.7K 5% 2W	01121	GB4725	101639	2
10	R108, R114	4	RESISTOR, CC 18K 5% 1W	01121	GB1835	101643	2
11		1-4	LUG #10	79963	622-.196	100491	4
12		1-4	PLATE, Mtg. PC Board	52542	065385	065385	1
13		1-4	SPACER 6-32 3/8/9	06540	9738-SS-0632	103394	2
14		1-4	ASSEMBLY Cable	52542	06542301	06542301	1
15	T101	1	TRANSFORMER	52542	504329	504329	1
15	T101	2	TRANSFORMER	52542	504330	504330	1
15	T101	3	TRANSFORMER	52542	504331	904331	1
15	T101	4	TRANSFORMER	52542	504332	504332	1
16		1-4	SCREW, PHMS 6-32X3/8	96906	MS51957-28	10063206	8
17		1-4	WASHER, Split #6	96906	MS35338-136	100712	15
18		1-4	SCREW, PHMS 6-32X5/16	96906	MS51957-27	10063205	8
19		1-4	NUT, Kep 6-32	78189	511-061800-00	100862	12
20		1-4	SCREW, PHMS 6-32X7/16	96906	MS51957-29	10063207	3
21		1-4	WASHER, Flat #6	96906	MS15795-805	100714	15
22		1-4	SCREW, PHMS 6-32X1/2	96906	MS51957-30	10063208	1
23		1-4	NUT, Hex 6-32	96906	MS35649-264	100706	2
24		1-4	NUT, Kep 8-32	78189	511-081800-00	100940	1
25		1-4	SCREW, FHMS 6-32X5/16	96906	MS24693-C25	10072105	3
26		1-4	SCREW, PHMS Cres 6-32X9/16	08547	By Description	100851	4
27		1-4	SCREW, PHMS 4-40X7/16	96906	MS51957-16	10062607	2
28		1-4	WASHER, Split #4	96906	MS35338-135	100711	2
29		1-4	WASHER, Flat #4	96906	MS15795-803	100703	2
30		1-4	PLATE, Name	52542	T101040	T101040	1
31		1-4	JUMPER	55210	L-2007-1	102879	
32	C103, C104	1-4	CAPACITOR, Ceramic .05µF 200V	72982	845-024	800168	2
33		1-4	CABLE, AC Twisted	52542	06542501	06542501	1
34		1-4	WASHER, Flat #10	96906	MS15795-808	100648	4

1=PH10-10 2=PH20-6 3=PH50-3 4=PH100-1.5

REPLACEABLE PARTS LIST

TITLE PH SERIES CHASSIS ASSEMBLY

ITEM	REF	USED ON	COMPONENT DESCRIPTION	MFR'S CODE	MANUFACTURER'S PART NUMBER	SD STOCK NUMBER	T/Q
35		1-4	NUT, Hex #10	96906	MS35650-104	100709	4
36		1-4	WASHER, Split #10	96906	MS35338-138	100714	4
37		1-4	SCREW, PHMS 10-32X1/2	96906	MS51958-63	10064408	4
38		1-4	LABEL, Caution	52542	065535	065535	1

1=PH10-10 2=PH20-6 3=PH50-3 4=PH100-1.5

REPLACEABLE PARTS LIST

TITLE PH SERIES FRONT PANEL ASSEMBLY

ITEM	REF	USED ON	COMPONENT DESCRIPTION	MFR'S CODE	MANUFACTURER'S PART NUMBER	SD STOCK NUMBER	T/Q
		1	ASSEMBLY, Front Panel	52542	06538101	06538101	1
		2	ASSEMBLY, Front Panel	52542	06538102	06538102	1
		3	ASSEMBLY, Front Panel	52542	06538103	06538103	1
		4	ASSEMBLY, Front Panel	52542	06538104	06538104	1
1		1-4	PANEL, Front	52542	065381	065381	1
2		1-4	ASSEMBLY, Indicator PCB	52542	06539901	06539901	1
3	M101	1	ASSEMBLY, Volt Meter	52542	06539901	06539901	1
3	M101	2	ASSEMBLY, Volt Meter	52542	065401	065401	1
3	M101	3	ASSEMBLY, Volt Meter	52542	06539201	06539201	1
3	M101	4	ASSEMBLY, Volt Meter	52542	06539301	06539301	1
4	M102	1	ASSEMBLY, Amp Meter	52542	06539401	06539401	1
4	M102	2	ASSEMBLY, Amp Meter	52542	065402	065402	1
4	M102	3	ASSEMBLY, Amp Meter	52542	06539501	06539501	1
4	M102	4	ASSEMBLY, Amp Meter	52542	06539601	06539601	1
5	J103	1-4	TEST JACK, Black	74970	105-0253-001	T920190	1
6	J102	1-4	TEST JACK, Red	74970	105-0252-001	T920260	1
7	S101	1-4	SWITCH, Toggle SPST	73559	LTA111-TR8	117470	1
8	R110	1-4	RESISTOR, Variable 100Ω 10% 1/2W	32997	3540S	600043	1
9	R112	1	RESISTOR, Variable 10K 10% 2W WW	11534	3253	106149	1
9	R112	2	RESISTOR, Variable 20K 10% 1/2W	73138	7276R20K	600374	1
9	R112	3	RESISTOR, Variable 50K 10% 1/2W	80294	3540-1-503	102913	1
9	R112	4	RESISTOR, Variable 100K 10% 1/2W	32997	3540S	600455	1
10		1-4	SHIELD, Cover	52542	06542202	06542202	1
11		1-4	SHIELD, Pot	52542	06542201	06542201	1
12		1-4	KNOB	86797	RB-67-1-DC-M-L	100976	2
13		1-4	WASHER, Internal-tooth	52542	T990190	T990190	2
14		1-4	WASHER, Flat 3/8 ID	96906	AN960-616L	T990043	2
15		1-4	WASHER, Flat #6	96906	MS15795-805	100704	3

1=PH10-10 2=PH20-6 3=PH50-3 4=PH100-1.5

REPLACEABLE PARTS LIST

TITLE PH SERIES FRONT PANEL ASSEMBLY

ITEM	REF	USED ON	COMPONENT DESCRIPTION	MFR'S CODE	MANUFACTURER'S PART NUMBER	SD STOCK NUMBER	T/Q
16		1-4	NUT, Kep #6	78189	511-061800-00	100862	3
17		1-4	WASHER, Internal-tooth	78189	1214-05	103004	2
18		1-4	NUT, Hex 1/4-32	01121	M-4721	100671	2
19		1	LABEL, Foilcal	52542	781687	781687	1
19		2	LABEL, Foilcal	52542	781688	781688	1
19		3	LABEL, Foilcal	52542	781689	781689	1
19		4	LABEL, Foilcal	52542	781690	781690	1
21		1-4	GROMMET	83330	2175	T910010	1
22		1-4	SPACER, Rnd. 7/16	06540	9227-A-171-17	117785	3

1=PH10-10 2=PH20-6 3=PH50-3 4=PH100-1.5

REPLACEABLE PARTS LIST

TITLE PH SERIES REAR PANEL ASSEMBLY

ITEM	REF	USED ON	COMPONENT DESCRIPTION	MFR'S CODE	MANUFACTURER'S PART NUMBER	SD STOCK NUMBER	T/Q
		1	ASSEMBLY, Rear Panel	52542	06538201	06538201	1
		2	ASSEMBLY, Rear Panel	52542	06538202	06538202	1
		3	ASSEMBLY, Rear Panel	52542	06538203	06538203	1
		4	ASSEMBLY, Rear Panel	52542	06538204	06538204	1
1		1-4	PANEL, Rear	52542	065382	065382	1
2		1-4	HEAT SINK	52542	065384	065384	1
3	S102	1-4	SWITCH, Thermal	14604	2450-88-16	880007	1
4	R106	1	RESISTOR 25Ω 10W	83777	FR10	640262	1
4	R106	2	RESISTOR, WW 100Ω 12W 5%	12697	VPR10F-100	117666	1
4	R106	3	RESISTOR, WW 700Ω 12W 5%	12697	VPR10F-700	117667	1
4	R106	4	RESISTOR, 2.5K 10W 5%	83777	VL0010-4250	640543	1
5	Q101 thru Q104	1,2	TRANSISTOR, SINPN	80103	PMD16K40	117649	4
5	Q101 thru Q104	3,4	TRANSISTOR, SINPN	80103	PMD16K100	117650	4
6	R101 thru R104	1	RESISTOR, WW .05Ω 3% 3W	15915	TS3.05 3%	117651	4
6	R101 thru R104	2	RESISTOR, WW .1Ω 3% 3W	15915	TS2D	630003	4
6	R101 thru R104	3	RESISTOR, WW .2Ω 3% 3W	15915	TS2D	630004	4
6	R101 thru R104	4	RESISTOR, WW 1Ω 3% 3W	15915	TS2D	630030	4
7	R105	1	RESISTOR, WW .2Ω 3% 3W	15915	TS2D	630000	1
7	R105	2	RESISTOR, WW .3Ω 3% 3W	15915	TS2D	630006	1

1=PH10-10 2=PH20-6 3=PH50-3 4=PH100-1.5

REPLACEABLE PARTS LIST

TITLE PH SERIES REAR PANEL ASSEMBLY

ITEM	REF	USED ON	COMPONENT DESCRIPTION	MFR'S CODE	MANUFACTURER'S PART NUMBER	SD STOCK NUMBER	T/Q
7	R105	3	RESISTOR, WW .7Ω 3% 3W	15915	TS2D	630020	1
7	R105	4	RESISTOR, WW 2Ω 3% 3W	15915	TS2D	630060	1
8	R111	1-4	RESISTOR, CC 1K 5% 1/4W	01121	CB1025	101569	1
9	Q105	1-3	TRANSISTOR	04713	2N3447	705071	1
9	Q105	4	TRANSISTOR, SINPN	16758	DTS411	700429	1
10	XQ101 thru XQ105	1-4	SOCKET, Transistor to 3	06776	MD-3452-G	830099	5
11	XF101	1-4	HOLDER, Fuse for 3AG	75915	345002	117381	1
12	F101	1-4	FUSE, 3A Slo Blo	71400	MDX-3	870180	1
13		1-4	WASHER, Internal-tooth	78189	1224-02	T990200	1
15	1-4	1-4	LINE CORD	70903	17237B	102406	1
16		1-4	STRAIN RELIEF	28520	SR-5P-4	103002	1
17	TB101	1-4	BARRIER STRIP	75382	599-2004-5	850052	1
18		1-4	LINKS, Shorting	52542	840217	840217	2
19		1-4	GUIDE, Card	23880	1450F	100855	1
20	1-4	1-4	GROMMET	06915	PGS-2	117739	2
21		1-4	PLATE, Insulator	52542	065388	065388	1
22	CR102	1-4	DIODE, SCR	03508	C35B	720000	3
23		1-4	STANDOFF #4	17117	2304-91-1	860020	3
24		1-4	WASHER, Mica	08289	DM-101	T990290	5
25	C107	1,2, 4	CAPACITOR, Film 1µF 200V	52763	MKT1813-510/25	800304	1
25	C107	3	CAPACITOR 2.2µF 250V	27556	ZA2Z225K	800325	1
26	C108	1	CAPACITOR, Tant. 15µF 10% 20V	56289	150D156X9020B2	100211	1
26	C108	2	CAPACITOR, Tant. 6.8µF 10% 35V	56289	150D685X9035B	100182	1
26	C111	3,4	CAPACITOR, Ceramic .01µF 20% 500V	91418	Type SM	100075	1
27	C109	1	CAPACITOR, Tant. 2.2µF 10% 35V	56289	150D225X9035B2	100100	1

1=PH10-10 2=PH20-6 3=PH50-3 4=PH100-1.5

REPLACEABLE PARTS LIST

TITLE PH SERIES REAR PANEL ASSEMBLY

ITEM	REF	USED ON	COMPONENT DESCRIPTION	MFR'S CODE	MANUFACTURER'S PART NUMBER	SD STOCK NUMBER	T/Q
27	C108	2	CAPACITOR, Tant. 6.8µF 10% 35V	56289	150D685X9035B	100182	1
27	C111	3	CAPACITOR, Ceramic .01µF 20% 500V	91418	Type SM	100075	1
27	C112	4	CAPACITOR, Tant 10µF 10% 10V	56289	196D106X9020JA1	103715	1
28		1-4	SCREW, PHMS 6-32X9/16	08547	By Description	100851	10
29		1-4	WASHER, Split #6	96906	MS35338-136	100712	15
30	R113	1-4	RESISTOR, CC 1K 1/4W 5%	01121	CB1025	101569	1
31		1-4	SCREW, PHMS 6-32X2 1/4	08547	By Description	10063236	1
32		1-4	WASHER, Flat #6	96906	MS15795-805	100704	3
33		1-4	WASHER, Fiber	83330	2163	100974	2
34		1-4	NUT, Kep 6-32	78189	511-061800-00	100862	1
35		1-4	SCREW, PHMS 6-32X3/8	96906	MS51957-28	10063206	3
36		1-4	INSULATOR	81483	40-9034	T990340	1
37		1-4	WASHER, Mica	52542	T990295	T990295	2
38		1-4	LUG	81483	40-112	T960640	1
39		1-4	WASHER, Internal-tooth #4	96906	MS35333-70	T990180	1
40		1-4	NUT, Hex	96906	MS35650-3252	T980128	1
41		1-4	WASHER, Flat	52542	T990040	T990040	1
42		1-4	SCREW, PHMS 2-56X1/4	96906	MS51957-3	10062504	2
43		1-4	WASHER, Split #2	96906	MS35337-77	100661	2
44		1-4	LUG	Pd1	S491020VF	T960560	1
45		1-4	LUG	06383	DVC18-250F1	117852	2
46		1-4	WASHER, Split #4	96906	MS35338-135	100711	3
47		1-4	SCREW, PHMS 4-40X5/16	96906	MS51957-14	10062605	3
48		1-4	SCREW, PHMS 6-32X5/8	96906	MS51957-31	10063210	1
49		1-4	COVER, Protective	52542	065427	065427	1
50		1-4	SPACER, Hex 6-32	83330	8797	100827	2
51		1-4	ASSEMBLY, Input Connector Kit	52542	06542802	06542802	1
53	C110	1-4	CAPACITOR, Ceramic 1000pF 20% 1000V	91418	Type B	100076	

1=PH10-10 2=PH20-6 3=PH50-3 4=PH100-1.5

REPLACEABLE PARTS LIST

TITLE PH SERIES REAR PANEL ASSEMBLY

ITEM	REF	USED ON	COMPONENT DESCRIPTION	MFR'S CODE	MANUFACTURER'S PART NUMBER	SD STOCK NUMBER	T/Q
54	C111	1	CAPACITOR, Ceramic .01µF 500V	91418	Type SM	100075	1
54		2-4	SCREW, PHMS 6-32X3/4	96906	MS51957-32	10063212	1
55		1	CAPACITOR, Tant. 10µF 10% 10V	56289	196D106X9020JA1	103715	1
55		2-4	STANDOFF 6-32	88245	14508	100471	1
56		1-4	LUG	07859	C136-06	117808	2
57	CR109	1-3	DIODE, Rectifier	81349	1N5401	710454	1
57	CR109	4	DIODE	04713	1N5395	100413	1
58	R115	2	RESISTOR, WW .1Ω 5% 3W	15915	R53..1 5%NI	117797	1
58	R115	3,4	RESISTOR, WW .33Ω 5% 3W	15915	T53 .33 5%NI	117798	1
59		1-4	WASHER, Split #6	96906	MS35338-136	T990220	2
60	F101	1-4	FUSE, 3AGSB (208V-240V only)	75915	31301.5	100591	1
61	C112	2	Same as 27				

1=PH10-10 2=PH20-6 3=50-3 4=PH100-1.5

REPLACEABLE PARTS LIST

TITLE PH SERIES PC BOARD ASSEMBLY

ITEM	REF	USED ON	COMPONENT DESCRIPTION	MFR'S CODE	MANUFACTURER'S PART NUMBER	SD STOCK NUMBER	T/Q
		1	ASSEMBLY, PC Board	52542	06536701	06536701	1
		2	ASSEMBLY, PC Board	52542	06536702	06535602	1
		3	ASSEMBLY, PC Board	52542	06536703	06536703	1
		4	ASSEMBLY, PC Board	52542	06536704	06536704	
	C1	1-4	CAPACITOR, Ceramic .01µF 100V +80-20%	91418	TA110	100103	2
	C2	1-4	Same as C1				
	C3	1-4	CAPACITOR, El Ax 470µF 40V	99392	ET471X040A02	103383	1
	C4	1-4	CAPACITOR, D. Mica 330pF 500V 5%	72136	DM15FD331J0	100276	2
	C5	1-4	CAPACITOR, Tant 15µF 20V 10%	56289	150D156X9020B2	100211	3
	C6	1-4	CAPACITOR, El Ax 470µF 16V	25088	B41283-470/16	117269	1
	C7	1-4	Same as C5				
	C8	1-4	CAPACITOR, D. Mica 27pF 500V 5%	72136	DM15ED27050	102545	1
	C9	1-4	CAPACITOR, D. Mica 510pF 500V 5%	72136	DM15Fd511J0	102579	1
	C10	1-4	CAPACITOR, D. Mica 150pF 500V 5%	72136	DM15FD151J0	100219	1
	C11	1	CAPACITOR, Mylar .022µF 200V 10%	56289	192P22392	100130	1
	C11	2	CAPACITOR, Mylar .01µF 200V 10%	56289	192P10392	100168	1
	C11	3	CAPACITOR, Mylar 2200pF 200V 10%	56289	192P22292	100185	4
	C11	4	Same as C11 (3)				
	C12	1,2	CAPACITOR, Met Mylar 1µF 100V 20%	14752	210B1B105	100056	1
	C12	3,4	CAPACITOR, Met Mylar .47µF 200V 20%	12406	ZD2A474	102584	1
	C13	1	CAPACITOR, Ceramic .01µF 50V 20%	71590	UK50-103	117351	1
	C13	2	CAPACITOR, Caeamic .005µF 500V 20%	91418	SM250	100077	1

1=PH10-10 2=PH20-6 3=PH50-3 4=PH100-1.5

REPLACEABLE PARTS LIST

TITLE PH SERIES PC BOARD ASSEMBLY

ITEM	REF	USED ON	COMPONENT DESCRIPTION	MFR'S CODE	MANUFACTURER'S PART NUMBER	SD STOCK NUMBER	T/Q
	C13	3	CAPACITOR, Ceramic 200pF 10% 100V	72982	8121-100W5R222K	102623	1
	C13	4	CAPACITOR, D. Mica 1000pF 5% 100V	72136	DM15FA102J0	100243	1
	C14	1-4	Same as C11 (3)				
	C15	1-4	Same as C11 (3)				
	C16	1-4	CAPACITOR, Tant 1µF 10% 35V	56289	196D105X9035HA1	103416	1
	C17	1-4	CAPACITOR, D. Mica 18pF 5% 500V	72136	DM15CD180J0	100242	1
	C18	1-4	Same as C1				
	C19	1-4	Same as C5				
	C20	1-4	CAPACITOR, Tant 56µF 10% 6V	56289	150D566X9006B2	100225	2
	C21	1-4	Same as C20				
	C22	1,4	Not Used				
	C22	2	CAPACITOR, Mylar .001µF 10% 200V	56289	192P10292	100137	1
	C22	3	Same as C11 (3)				
	C23	1-4	CAPACITOR, Mylar 4700pF 10% 200V	56289	192P47292	100129	1
	C24	1-4	Not Used				
	C25	1-4	Not Used				
	C26	1-4	Same as C4				
	C27	1-4	CAPACITOR, Met Mylar .033µF 100V	99515	DI-333E	100142	1
	CR1	1-4	DIODE, Rectifier	04713	1N5395	100413	12
	CR2	1-4	Same as CR1				
	CR3	1-4	DIODE, Zener 5.6V	03877	1N752A	100376	2
	CR4	1-4	DIODE, Reference 9V	04713	1N936	106551	1
	CR5 thru CR8	1-4	Same as CR1				
	CR9	1-4	DIODE, Zener 6.8V	04713	1N957B	100416	4
	CR10	1-4	Not Used				

1=PH10-10 2=PH20-6 3=PH50-3 4=PH100-1.5

REPLACEABLE PARTS LIST

TITLE PQ SERIES PC BOARD ASSEMBLY

ITEM	REF	USED ON	COMPONENT DESCRIPTION	MFR'S CODE	MANUFACTURER'S PART NUMBER	SD STOCK NUMBER	T/Q
	CR11	1-4	Same as CR1				
	CR12	1-4	Same as CR1				
	CR13 thru CR23	1-4	DIODE, Signal	03508	1N4151	100385	17
	CR24	1-4	Same as CR9				
	CR25	1-4	DIODE, Zener 15V	04713	1M965B	100383	1
	CR26	1-4	Same as CR13				
	CR27	1-4	Same as CR13				
	CR28	1-4	DIODE, Zener 10V	04713	1N961B	100395	2
	CR29	1-4	Same as CR13				
	CR30	1-4	Same as CR1				
	CR31	1-4	Same as CR13				
	CR32	1-4	Same as CR28				
	CR33	1-4	Same as CR9				
	CR34	1-4	Not Used				
	CR35	1-4	DIODE, Reference 6.2V	04713	1N823	720461	1
	CR36	1-4	Same as CR1				
	CR37	1-4	Same as CR1				
	CR38	1-4	Same as CR13				
	CR39	1-4	Same as CR9				
	CR40	1-4	Same as CR13				
	CR41	1-4	Same as CR3				
	CR42	1-4	Same as CR1				
	CR43	1-4	DIODE, Zener 5.1V	03877	1N751A	100378	1
	CR44	1-4	DIODE, Zener 12V	04713	1N759A	720173	1
	J1	1-4	CONNECTOR	05574	2VH10/1AN12	117662	1
	Q1	1-4	TRANSISTOR	81349	2N4340	705069	1
	Q2	1-4	TRANSISTOR, SINPN	07263	PN3643-5	101358	4
	Q3	1-3	TRANSISTOR, SIPNP	04713	2N2905A	705067	3
	Q3	4	TRANSISTOR	04713	MM4001	705066	3
	Q4	1-4	Same as Q2				
	Q5	1-4	TRANSISTOR, SIPNP	04713	2N3906	101378	4

1=PH10-10 2=PH20-6 3=PH50-3 4=PH100-1.5

REPLACEABLE PARTS LIST

TITLE PH SERIES PC BOARD ASSEMBLY

ITEM	REF	USED ON	COMPONENT DESCRIPTION	MFR'S CODE	MANUFACTURER'S PART NUMBER	SD STOCK NUMBER	T/Q
	Q6	1-4	Same as Q5				
	Q7	1-3	Same as Q3				
	Q7	4	Same as Q3 (4)				
	Q8	1-4	Same as Q5				
	Q9	1-3	Same as Q3				
	Q9	4	Same as Q3 (4)				
	Q10	1,2	Same asQ2				
	Q10	3,4	TRANSISTOR, SINPN	07263	2N5831	102676	1
	Q11	1-4	Same as Q5				
	Q12	1-4	Same as Q2				
	R1	1-4	RESISTOR, MF 13.7K 1% 1/8W	19701	MF5C-D-1372-F	102172	1
	R2	1-4	RESISTOR, MF 100K 1% 1/8W	91637	MFF 1/8 T1	102080	1
	R3	1-4	RESISTOR, MF 10K 1% 1/8W	19701	MF5C-D-1002-F	102198	2
	R4	1-4	RESISTOR, MF 150Ω 1% 1/8W	81349	RN60D1500F	106220	1
	R5	1-4	RESISTOR, CC 10K 5% 1/4W	01121	CB1035	101570	2
	R6	1-4	RESISTOR, CC 2.2K 5% 1/4W	01121	CB2225	101562	1
	R7	1,2	RESISTOR, CC 100Ω 5% 1/4W	01121	CB1015	101609	2
	R7	3,4	RESISTOR, CC 200Ω 5% 1/4W	01121	CB2015	101555	1
	R8	1-4	Not Used				
	R9	1-4	Not Used				
	R10	1-4	RESISTOR, CC 1K 5% 1/4W	01121	CB1025	101569	1
	R11	1-4	Not Used				
	R12	1,2	Same as R7				
	R12	3,4	RESISTOR, CC 100Ω 5% 1/4W	01121	CB1015	101609	1
	R13	1-4	RESISTOR, CC 6.8K 5% 1/4W	01121	CB6825	101544	4

1=PH10-10 2=PH20-6 3=PH50-3 4=PH100-1.5

REPLACEABLE PARTS LIST

TITLE PH SERIES PC BOARD ASSEMBLY

ITEM	REF	USED ON	COMPONENT DESCRIPTION	MFR'S CODE	MANUFACTURER'S PART NUMBER	SD STOCK NUMBER	T/Q
	R14	1-4	RESISTOR, Variable 1K 10% 3/8W	73138	89PR1K	1021181	2
	R15	1-4	RESISTOR, MF 8.45K 1% 1/4W	81349	RN65E8451F	117777	1
	R16	1-4	RESISTOR, CC 10M 5% 1/4W	01121	CB1065	101564	2
	R17	1-4	RESISTOR, CC 2.4M 5% 1/4W	01121	CB2455	106002	2
	R18	1-4	RESISTOR, Variable 10K 10% 1/2W	80294	68WR10K	117399	2
	R19	1-4	RESISTOR, CC .15K 5% 1/4W	01121	CB1535	101552	1
	R20	1	RESISTOR, MF 10K 1% 1/8W	19701	MF5C-E-1002-F	101930	2
	R20	2,3	RESISTOR, MF 12.4K 1% 1/8W	81349	RN60E1242F	102045	1
	R20	4	RESISTOR, MF 15K 1% 1/8W	19701	MF5C-E-1502-F	101928	1
	R21	1-4	RESISTOR, MF 4.99K 1% 1/8W	81349	RN60C4991F	106364	1
	R22	1	Same as R20 (1)				
	R22	2	RESISTOR, MF 20K 1% 1/8W	91637	MFF 1/8 T9	103015	1
	R22	3	RESISTOR, MF 49.9K 1% 1/8W	81349	RN60E4992F	102296	1
	R22	4	RESISTOR, MF 100K 1% 1/4W	81349	RN65E1003F	117653	1
	R23	1-4	RESISTOR, MF 4.87K 1% 1/8W	81349	RN60E4871F	117776	2
	R24	1-4	RESISTOR, Variable 500 10% 3/8W	73138	89PR500	102183	1
	R25	1-4	RESISTOR, CC 390 5% 1/4W	01121	CB3915	101592	3
	R26	1-4	Same as R25				
	R27	1-4	Same as R25				
	R28	1-4	RESISTOR, MF 1.82K 1% 1/8W	81349	RN60C1821F	106160	1
	R29	1-4	Same as R3				

1=PH10-10 2=PH20-6 3=PH50-3 4=PH100-1.5

REPLACEABLE PARTS LIST

TITLE PH SERIES PC BOARD ASSEMBLY

ITEM	REF	USED ON	COMPONENT DESCRIPTION	MFR'S CODE	MANUFACTURER'S PART NUMBER	SD STOCK NUMBER	T/Q
	R30	1	RESISTOR, MF 10K .1% 1/8W	81349	RN60C1821F	106070	2
	R30	2-4	Same as R30				1
	R31	1	Same as R30				
	R31	2	RESISTOR, MF 20K .1% 1/8W	81349	RN60C2002F	117663	1
	R31	3	RESISTOR, MF 50K .1% 1/8W	81349	RN60C5002F	106356	1
	R31	4	RESISTOR, MF 100K 1.% 1/8W	91637	CMF60T9	103423	1
	R32	1-4	Not Used				
	R33	1-4	RESISTOR, CC 330Ω 5% 1/4W	01121	CB3315	101536	1
	R34	1-4	RESISTOR, CC 820Ω 5% 1/4W	01121	CB8215	101567	3
	R35	1-4	RESISTOR, MF 499Ω 1% 1/8W	16299	NA60D4990F	106250	1
	R36	1-4	RESISTOR, MF 31.6K 1% 1/8W	19701	MF5C-D-3162F	102941	1
	R37	1-4	RESISTOR, CC 22K 5% 1/4W	01121	CB2235	101572	5
	R38	1-4	Same as R13				
	R39	1-4	Same as R13				
	R40	1-4	Same as R37				
	R41	1-4	RESISTOR, CC 510Ω 5% 1/4W	01121	CB5115	101616	2
	R42	1-4	Same as R34				
	R43	1-4	RESISTOR, CC 1.5K 5% 1/4W	01121	CB1525	101577	4
	R44	1-4	RESISTOR, CC 47K 5% 1/4W	01121	CB4735	101574	1
	R45	1-4	Same as R5				
	R46	1-4	RESISTOR, CC 22Ω 5% 1/4W	01121	CB2205	101696	1
	R47	1-4	Same as R43				
	R48	1-4	Same as R43				

1=PH10-10 2=PH20-6 3=PH50-3 4=PH100-1.5

REPLACEABLE PARTS LIST

TITLE PH SERIES PC BOARD ASSEMBLY

ITEM	REF	USED ON	COMPONENT DESCRIPTION	MFR'S CODE	MANUFACTURER'S PART NUMBER	SD STOCK NUMBER	T/Q
	R49	1-4	Same as R37				
	R50	1-4	Same as R13				
	R51	1-4	Same as R41				
	R52	1-4	Same as R16				
	R53	1-4	Same as R18				
	R54	1-4	Same as R37				
	R55	1-4	Not Used				
	R56	1	RESISTOR, CC 10Ω 5% 1/4W	01121	CB1005	101557	1
	R56	2	RESISTOR, CC 15Ω 5% 1/4W	01121	CB1505	101764	1
	R56	3	RESISTOR, CC 39Ω 5% 1/4W	01121	CB3905	101733	1
	R56	4	RESISTOR, CC 82Ω 5% 1/4W	01121	CB8205	101629	1
	R57	1-4	RESISTOR, MF 1K 1% 1/8W	19701	MF5C-D-1001-F	102097	1
	R58	1-4	RESISTOR, MF 90.9Ω 1% 1/8W	91637	MFF 1/8 T1	103087	1
	R59	1-4	RESISTOR, Variable 20Ω 10% 3/8W	73138	89PR20	102154	1
	R60	1-4	RESISTOR, MF 5.62K 1% 1/8W	81349	RN60C5621F	106194	1
	R61	1-4	Same as R14				
	R62	1-4	RESISTOR, Variable 100Ω 10% 1/2W	73138	72PR100	117188	1
	R63	1	RESISTOR, MF 9.53K 1% 1/8W	81349	RN60D9531F	106328	1
	R63	2	RESISTOR, MF 18.2K 1% 1/8W	19701	MF5C-D-1822-F	102139	1
	R63	3	RESISTOR, MF 47.5K 1% 1/8W	81349	RN60C4752F	106189	1
	R63	4	RESISTOR, MF 80.6K 1% 1/8W	19701	MF5C-D-1822-F	102139	1
	R64	1	RESISTOR, Variable 1K 10% 3/8W	73138	72PR1K	103787	1

1=PH10-10 2=PH20-6 3=PH50-3 4=PH100-1.5

REPLACEABLE PARTS LIST

TITLE PH SERIES PC BOARD ASSEMBLY

ITEM	REF	USED ON	COMPONENT DESCRIPTION	MFR'S CODE	MANUFACTURER'S PART NUMBER	SD STOCK NUMBER	T/Q
	R64	2,3	RESISTOR, Variable 5K 10% 3/8W	73138	72PR5K	103788	1
	R64	4	RESISTOR, Variable 50K 10% 3/8W	73138	62PR50K	101905	1
	R65	1-4	Not Used				
	R66	1-4	Same as R37				
	R67	1-4	RESISTOR, CC 100K 5% 1/4W	01121	CB1045	101558	1
	R68	1-4	Same as R43				
	R69	1-4	RESISTOR, CC 270Ω 5% 1/4W	01121	CB2715	101542	1
	R70	1	RESISTOR, WW .01Ω 3% 5W	15915	TS5K .01 3%	117658	1
	R70	2	RESISTOR, WW .017Ω 3% 5W	15915	TS5K .017 3%	117659	1
	R70	3	RESISTOR, WW .033Ω 3% 5W	15915	TS5K .033 3%	117660	1
	R70	4	RESISTOR, WW .066Ω 3% 5W	15915	TS5K .067 3%	117661	1
	R71	1-4	Same as R17				
	R72	1-4	Same as R34				
	R73	1-4	Same as R23				
	S1	1-4	SWITCH, Slide TPDT	79727	GF165-005	117665	1
	S2	1-4	SWITCH, PB DPDT	95146	TSS21NG-RA	117664	2
	S3	1-4	Same as S2				
	U1	1-4	INTEGRATED CIRCUIT Op Amp	27014	LM301AH	025745	2
	U2	1-4	INTEGRATED CIRCUIT Op Amp	27014	LM201AH	025758	1
	U3	1-4	Same as U1				
	U4	1-4	INTEGRATED CIRCUIT Dual Op Amp	07263	747HC	103708	1

1=PH10-10 2=PH20-6 3=PH50-3 4=PH100-1.5

REPLACEABLE PARTS LIST

TITLE PH SERIES INDICATOR PC BOARD ASSEMBLY 06539901

ITEM	REF	USED ON	COMPONENT DESCRIPTION	MFR'S CODE	MANUFACTURER'S PART NUMBER	SD STOCK NUMBER	T/Q
1		1-4	BOARD, PC	52542	065399	065399	1
2	R109	1-4	RESISTOR, Variable 10K 10% 1/2W	73138	68WR10K	117399	1
3	CR103 thru CR105	1-4	LED, Green	50522	MV5253	103202	4
3	CR108	1-4	Same as CR103				
4	CR106	1-4	LED, Red	50522	MV5754	103960	1
5	CR107	1-4	LED, Orange	50522	MV5153	103201	1
6		1-4	FIXTURE, PC Board	52542	065426	065426	1

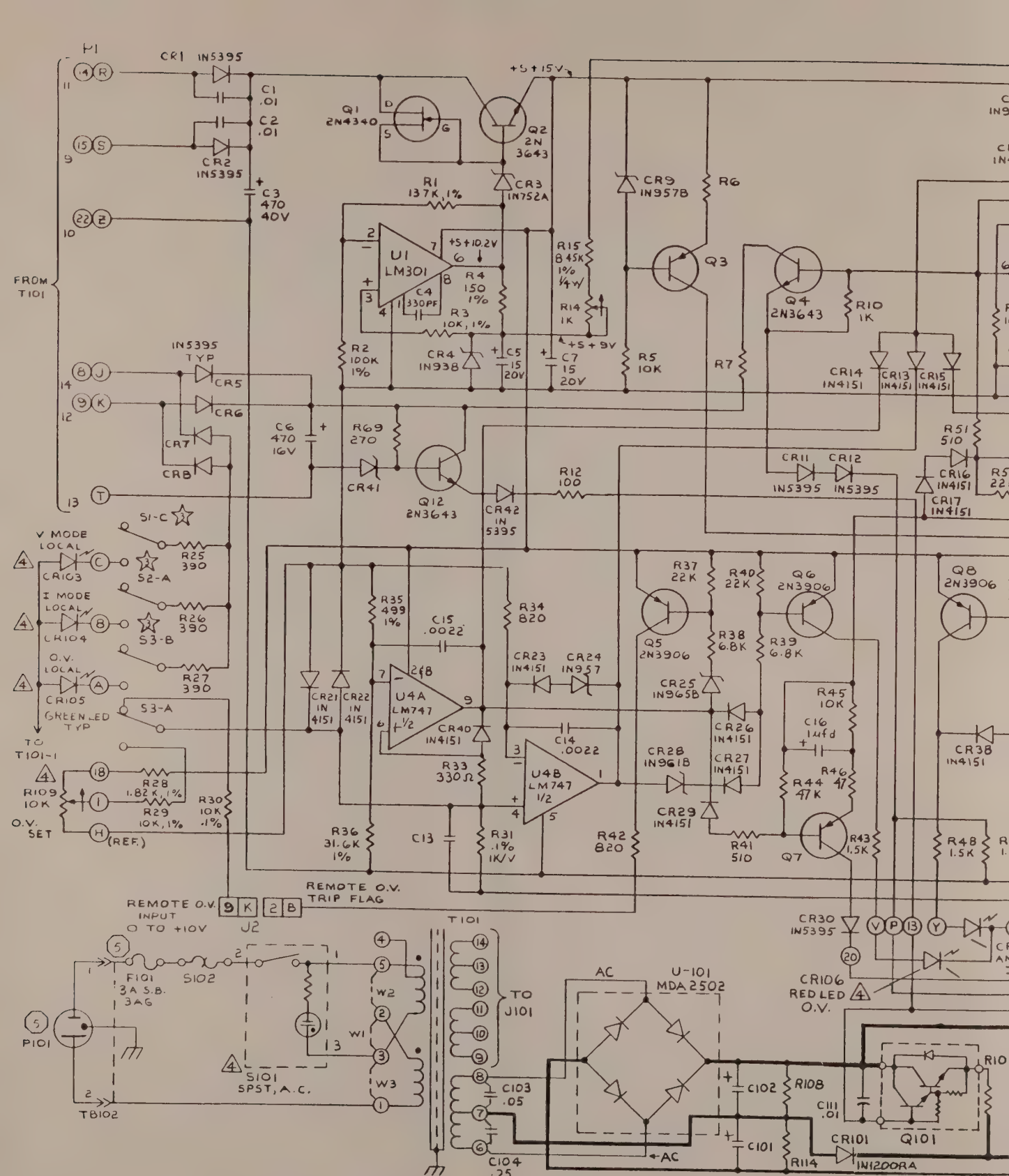
1=PH10-10 2=PH20-6 3=PH50-3 4=PH100-1.5

REPLACEABLE PARTS LIST

TITLE PH SERIES HEAT SINK ASSEMBLY 06541501

ITEM	REF	USED ON	COMPONENT DESCRIPTION	MFR'S CODE	MANUFACTURER'S PART NUMBER	SD STOCK NUMBER	T/Q
1		1-4	HEAT SINK	52542	065415	065415	1
2	V101	1-4	RECTIFIER, Bridge	04713	MD2502	117655	1
3		1-4	SCREW 8-32X1	52542	970621	970621	1
4		1-4	WASHER, Flat #8	96906	MS15795-807	100705	1
5		1-4	NUT, Hex #8	96906	NAS67108	100708	1
6	CR101	1-4	DIODE, Rectifier	04713	1N1200RA	725057	1
7		1-4	WASHER, Mica	81483	40-8022	T990350	1
8		1-4	NUT, Kep #10	78189	511-101800-50	100939	1
9		1-4	WASHER, Flat #10	96906	MS15795-808	100648	1
10		1-4	WASHER, Split #8	96906	MS35338-137	100713	1

1=PH10-10 2=PH20-6 3=PH50-3 4=PH100-1.5



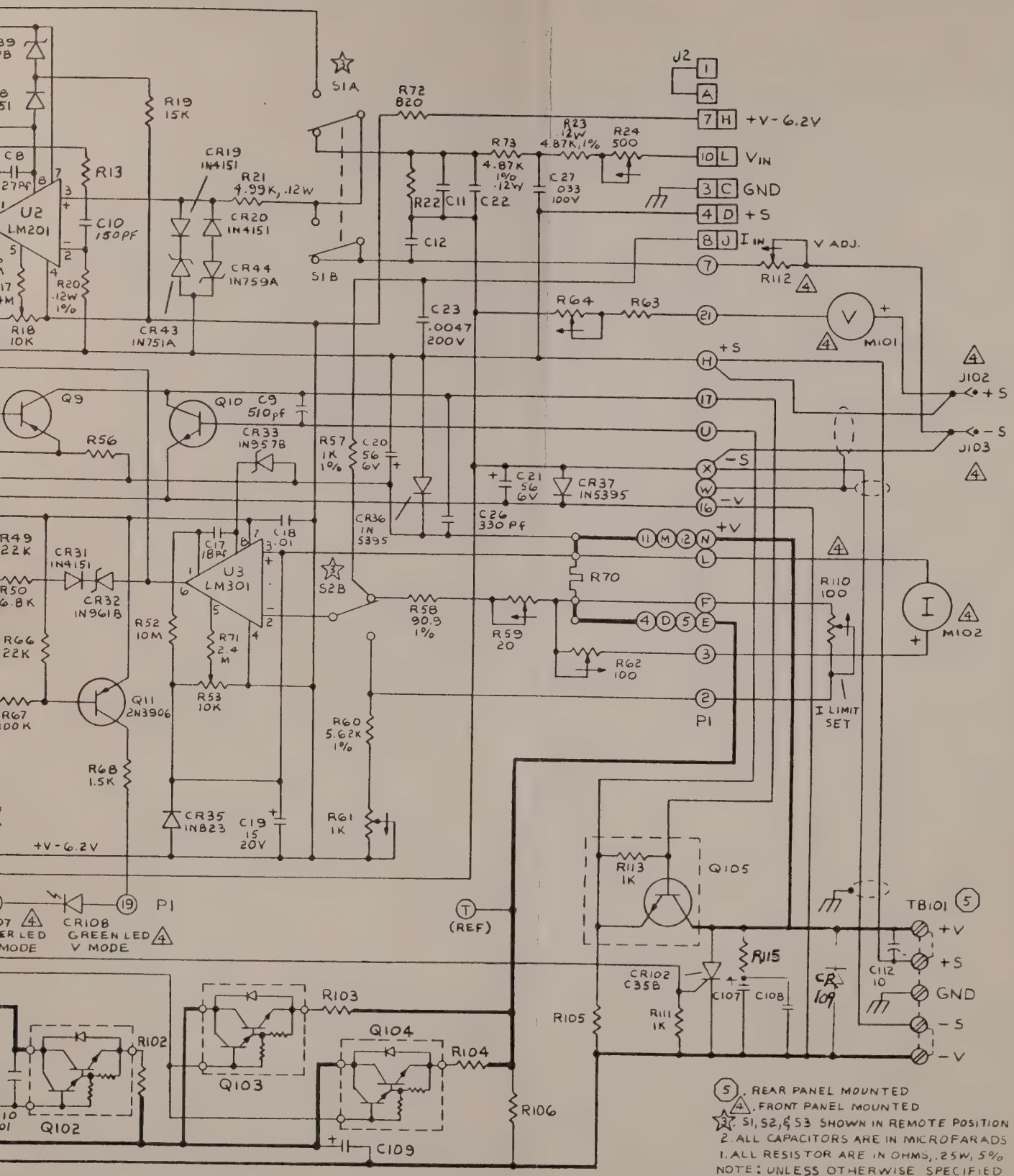
CHASSIS TABLE I

MODEL	C101 C102	R115	C109	Q101-Q104	Q105	R101-R104	R105	R106	R108 R114	R112	C107	C108	CR109
.10-10	6.4K 25V	WIRE	2.2	PMD 16K40	2N 3447	.05 3W	.2Ω 3W	25 10W	270 1W	10K 10T	1uf d	15 uf d	IN 5401
20-6	5CK 25V	.1Ω	NOT USED	PMD 16K40	2N 3447	.1Ω 3W	100 10W	470 2W	1K 5W	20K 10T	1uf d	6.8 uf d	IN 5401
50-3	23.8K 40V	.33Ω	NOT USED	PMD 4K100	2N 3447	.2 3W	700 10W	1K 5W	50K 10T	2.2 uf d	NOT USED		IN 5401
100-1.5	6.4K 100V	.33Ω	NOT USED	PMD 4K100	DTS 411	1Ω 3W	2Ω 3W	2.5K 10W	4K 5W	100K 10T	1uf d	NOT USED	IN 5395

P.C. CONTROL BOARD

C11	C12	C13	C22	Q3,Q7 Q9	Q10	CR41		R6	R7
.022	1	.01	NOT USED	2N 2905A	2N 3643	IN 750A		2.2K	100
.01	1	.005	.001	2N 2905A	2N 3643	IN 750A		2.2K	100
.0022	.47	.002	.0022	2N 2905A	2N 3831	IN 750A		2.2K	200
.0022	.47	.001	NOT USED	MM 4001	2N 5831	IN 752A		2.2K	200

PH SERIES-10-79



5. REAR PANEL MOUNTED
4. FRONT PANEL MOUNTED
3. S1, S2, & S3 SHOWN IN REMOTE POSITION
2. ALL CAPACITORS ARE IN MICROFARADS
1. ALL RESISTOR ARE IN OHMS, .25W, 5%
NOTE: UNLESS OTHERWISE SPECIFIED

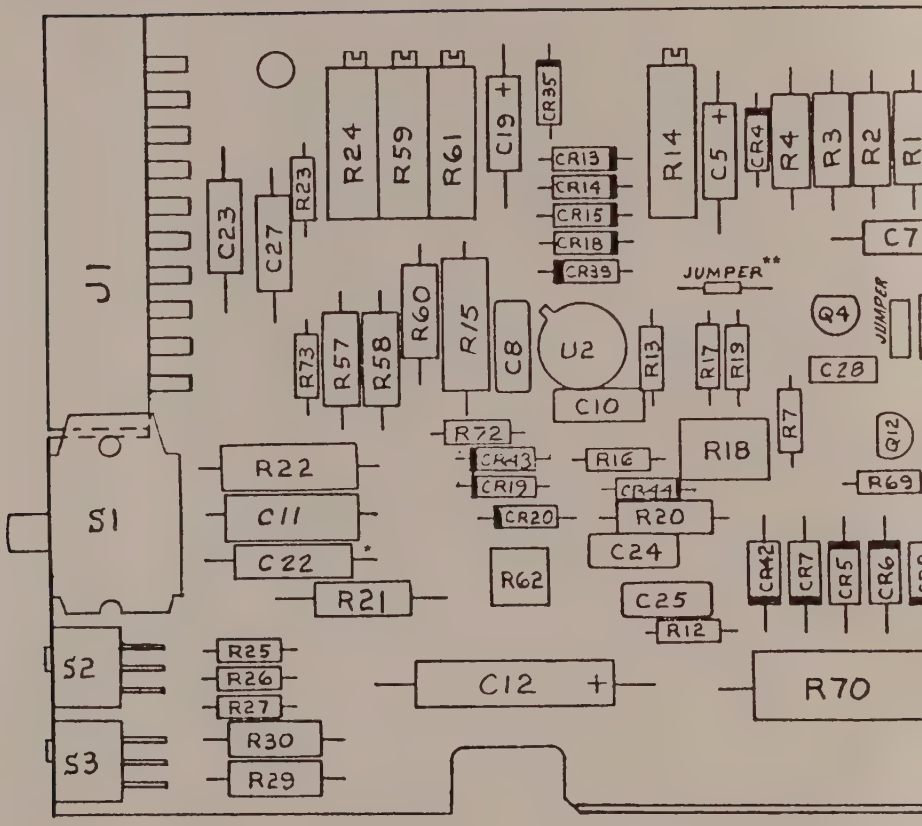
TABLE II

	R20	R22	R31		R56	R63	R64	R70
8	10K	10K	10K		10	9.53K	1K	.01
K	12.4K	20K	20K		15	18.2K	5K	.017
K	12.4K	499K	50K		39	47.5K	5K	.033
K	15K	100K	100K		82	90.0K	20K	.047

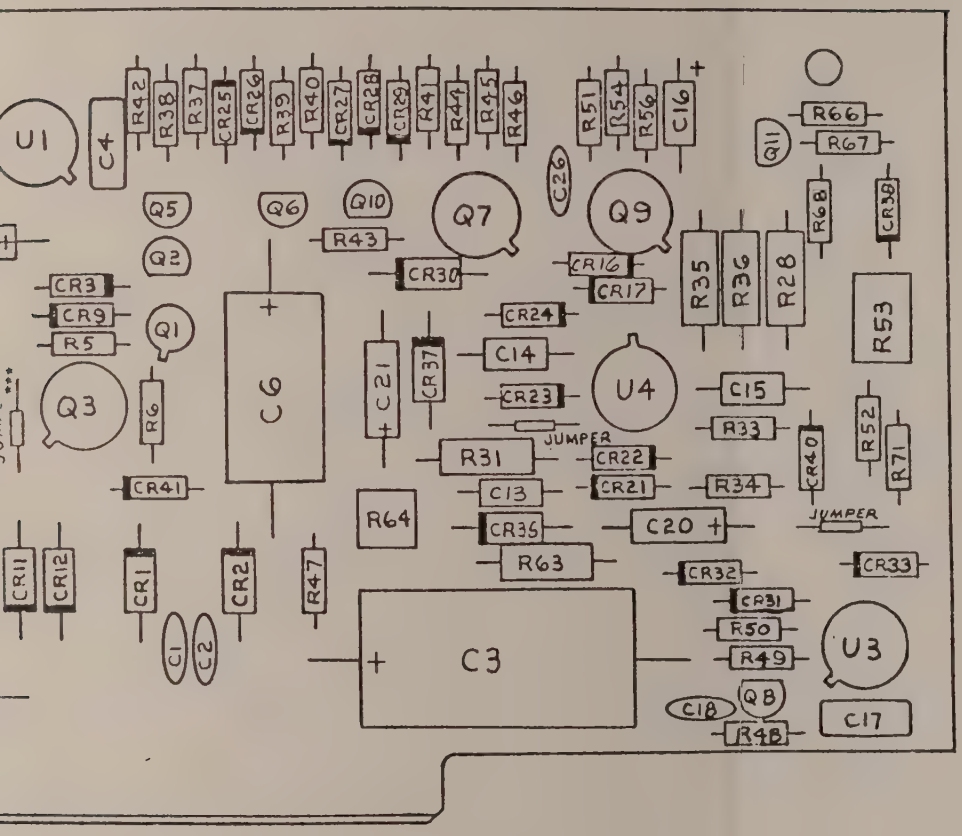
TRANSFORMER CONNECTIONS

VOLTAGE	FROM	TO	WIRE NO.
100	S101-1	T101-4	W2, W3
115/120	S101-1	T101-5	W2, W3
208/220	S101-1	T101-4	W1
230/240	S101-1	T101-5	W1

PH SERIES SCHEMATIC
7D065445



*C22 NOT USED ON PH100-1.5.
**JUMPER IS CALLED OUT R9 ON PH50-3.
***JUMPER IS CALLED OUT R11 ON PH50-3.



COMPONENT LOCATION DIAGRAM
FOR
PH 10-10; PH 20-6; PH 50-3 AND PH 100-1.5

Test Point or Component -lead of C102 to + lead of C101	Function	VOLTAGE (Vdc)							
		PQ10-3	PQ20-2	PQ50-1	PQ100-.5	PH10-10	PH20-6	PH50-3	PH100-1.5
	Main Output Filter	≈21	≈35	≈74	≈138	≈21	≈35	≈74	≈138
C3	Aux. Reg. Filter	≈30	→	→	→	→	→	→	≈ 30
CR3	Aux. Ref. Zener	5.6 ± .3	→	→	→	→	→	→	5.6 ± .3
CR4	+S +9V Ref. Zener	9 ± .4	→	→	→	→	→	→	9 ± .4
CR35	+V -6.2V Ref. Zener	6.2 ± .3	→	→	→	→	→	→	6.2 ± .3
C7	+S +15V Reference	15 ± .6	→	→	→	→	→	→	15 ± .6

Note: All voltage measurements are normal power supply operation, 115V nominal ac line input, and full rated output voltage and current.

P-Series Model	Output				Sink Current Limit ***	Input	
	Voltage Mode **		Current Mode			Voltage	Line Frequency
	Range *	Resistance	Range	Impedance			
PQ 10-3	0 to 10 Vdc	20 µΩ	0 to 3 A	5 k + 5.7 µF	3.5 A	All models:	All models:
PQ 20-2	0 to 20 Vdc	67 µΩ	0 to 2 A	10 k + 4.3 µF	2.3 A		
PQ 50-1	0 to 50 Vdc	333 µΩ	0 to 1 A	25 k + 2.2 µF	1.0 A	90-110 Vac	47-440 Hz
PQ100-0.5	0 to 100 Vdc	1.3 mΩ	0 to 0.5A	50 k + 1.0 µF	.35 A	104-127 Vac	
						194-237 Vac	
PH 10-10	0 to 10 Vdc	67 µΩ	0 to 10 A	5 k + 16 µF	3.5 A	207-253 Vac	
PH 20-6	0 to 20 Vdc	200 µΩ	0 to 6 A	10 k + 6.6 µF	2.3 A		
PH 50-3	0 to 50 Vdc	1.0 mΩ	0 to 3 A	25 k + 2.2 µF	1.0 A		
PH100-1.5	0 to 100 Vdc	4.0 mΩ	0 to 1.5A	50 k + 1.0 µF	.35 A		

Notes

* An extra 0.5 V per output lead compensates for sense lead voltage drop.
** Isolation voltage: 300V terminal to chassis.
*** Nominal value

3.2.5 Current Comparator Circuit

The current comparator circuit provides the constant current when in the current mode or current limiting when in the voltage mode.

The current sensing and comparison is accomplished by IC differential amplifier U3. A sampling of the output current is provided by monitoring the voltage drop across the current sensing resistor R70. The output end of resistor R70 is applied to U3 pin 3 as the +V signal.

When local current mode is selected the emitter output of the series pass transistor circuit is monitored via the front panel CURRENT control potentiometer R110 and applied to U3 pin 2. The LOCAL I CAL adjustment potentiometer R61 is connected between the +V -6.2V reference and U3 pin 2 to allow for the calibration of the front panel CURRENT control.

When remote current mode is selected U3 pin 2 receives its current limiting control via switch S2B from the rear panel programming connector J2 pins 8 and J as an 0 to -1 ma current input. The output of the series pass transistor circuit is monitored via the REMOTE I CAL adjustment potentiometer R69 to allow for the calibration of the remote current control scale factor.

The voltage difference developed between U3 pin 2 and 3 is the current error, which is amplified to generate the current control signal at U3 pin 6. The output at U3 pin 6 is applied to U2 pin 8 via diode CR15 which provides a variable clamping action to the voltage comparator U2, which in effect will increase or decrease the conduction of the series pass transistor circuit, thus maintaining a constant voltage across the current sensing resistor R70. When operating in the constant current mode, transistor Q8 is bias into conduction via diode CR31, there by causing the front panel I MODE amber LED indicator to illuminate. When transistor Q8 goes into conduction transistor Q11 is bias off via diode CR38 thus causing the front panel V MODE green LED indicator to extinguish.

The crossover between constant voltage to constant current mode is automatic. The point at which the operating mode automatically changes is a function of variation of the external load and occurs at a critical value of the load resistance $R_L = E_S/I_S$, where E_S is the voltage control setting and I_S is the current control setting.

3.2.6 V_{LIM} and Over Voltage Circuit

The voltage limiting (V_{LIM}) and over voltage (crowbar) protection functions are provided to protect the load or the power supply itself from over voltage due to programming, external voltage or internal malfunctions.

The V_{LIM} threshold can be set at any point from 5% to 109% of the power supplies rated output voltage by the front panel screwdriver adjustment V_{LIM} SET potentiometer R109 when local V_{LIM} is selected by switch S3A, or by a 0 to +10.9V level applied to the remote programming connector J2 pins 9 and 10 when remote V_{LIM} is selected by switch S3A. Switch S3B provides for the illumination of the V_{LIM} green LED CR105 when local V_{LIM} operation is selected. The over voltage crowbar threshold will track the V_{LIM} set point and trigger whenever the voltage across the +V and -V output terminals exceeds the V_{LIM} set point by 1% of the power supplies rated output voltage.